ABSTRACT

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(Under the direction of Dr. Gary A. Mirka and Dr. Carolyn Sommerich)

Student computer users are at risk for Musculoskeletal Disorders (MSDs), such as carpal tunnel syndrome and tendonitis, and tension neck syndrome. Past research has identified repetition, duration, and posture as contributors to the development of MSDs in the computer work environment and these risk factors are present in the activities of student computer users as well as professional computer users. A web-based questionnaire was administered to 234 undergraduate and graduate college students majoring in either engineering or humanities and social sciences. The results of this study were compared with the results of a previous survey of professional workers that has a similar question structure. Sixty four percent of college students reported assuming an awkward posture at least 'sometimes' while using a desktop computer. On the 24-hour clock, college students reported their computer use to be at least 'somewhat likely' between the hours of 8:00 a.m. – 2:00 a.m., while for professional workers the time period was reduced to the 12 hours between 6:00 a.m. – 6:00 p.m. The survey also showed that college students work on the computer for closer to 90 minutes before taking a break, while the professional workers worked closer to 60 minutes before taking a break. In participants under 35 years of age, graduate students reported on average 33.7 weekly computing hours, compared to the 35.2 hours reported by professional workers. In general, college students reported a higher frequency of upper extremity discomfort than professional workers, and female participants reported higher discomfort than their male counterparts. There is still much to be learned about college students'

interaction with computers, their risk of developing MSDs, and means by which risk can be reduced. The importance of incorporating ergonomics in the daily life of student computer users is apparent; it is believed that college students are likely to enter the workforce with poor computing habits and that appropriate education while the students are still in college is necessary to reduce the lifetime risk of developing these disorders.

College Student Computer Use and Ergonomics

By

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BIOGRAPHY

Karen Noack is the first of two children, the other being her younger brother, Kevin. Her father Carl, who raised Karen and her brother, still resides in Ellenton, FL, with his wife Mary. After graduating from high school in Palmetto, Karen received a Bachelor of Science degree in Industrial Engineering from the University of South Florida in Tampa. While at the USF, she had the privilege of working with Dr Paul McCright, who originally sparked the interest in Ergonomics and Safety.

Immediately following her undergraduate education, she traveled to Raleigh, North Carolina to attend North Carolina State University to work on a Master's degree in Industrial Engineering with a focus in Occupational Safety and Ergonomics. While working toward this, Karen had the honor of working with Dr. Carolyn Sommerich, contributing to a study on desktop and notebook computer users and ergonomics. In the next year, Karen had the honor of working with Dr. Gary A. Mirka, contributing to ergonomic intervention research in the furniture manufacturing industry.

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1 INTRODUCTION

1.1 Increasing Computer Use

Since 1985, worldwide personal computer use has grown from 6.5 per 1,000 people to 663 per 1,000 in 2002 (Computer 2003). No longer in just typical office settings, computers, also known as Personal Computers (PCs) or Visual Display Terminals (VDT), are present in the classroom, in libraries, even in retail stores for customer use. In 1984, 24.6% of employed adults used a computer on the job, and that figure doubled by 1997 to 49.8% (Newburger 1999). The National Science Foundation's investigations report rapid growth of PC ownership in the home (Papadakis 2000). Between 1984 and 1997, the percentage of households owning a computer climbed from 9% in 1984, to 26% in 1993, to 41% in 1997. The increase in PC ownership in the home during the four years from 1993-1997 was as rapid as the increase of the earlier nine year span, from 1984-1993 (US Census Bureau 1984, 1993, 1997). Household Internet use also rose from 2 percent in 1994 to 26 percent in 1998 (Papadakis 2000).

As computer utilization has increased at work and at home, computers are also being integrated into the education system, from elementary school to the university level. According to U.S. Census Bureau, "school is a major influence on children's access to computers". In 2000, 57% of the children ages 5-17 having access to computers at home, also had access to computers at school (PC 2000).

Over a five year period at the University of Massachusetts, the proportion of students with no experience with computers fell to almost zero (Kuenzi 1999-2000). During the beginning of the study, in 1991, one-tenth of the student participants used email. In 1996 two-thirds used email, and each year the use of word processing also increased. At the end of the five year study, the word processing use had increased about 50%. The participating students, over the course of this study, may have changed, but the pattern of increasing computer use could easily be extended to current students' trends, because the availability of computers at colleges and universities has continued to increase since 1996 (Kuenzi 1999-2000).

1.2 Computer Use, Ergonomics Awareness, and Musculoskeletal Discomfort

As computers expand our horizons, research and reports show some negative effects associated with computer use, such as Musculoskeletal Disorders (MSDs) or Repetitive Strain Injuries (RSIs). Among these are carpal tunnel syndrome, tendonitis, and tension neck syndrome. Risk factors that are singularly identified to contribute to MSDs are repetition, duration, force and posture, and there is strong evidence that jobs that require a combination of these factors increase risk for MSDs (Bernard 1997).

1.2.1 Adult Computer Users

Numerous studies exist relating adult workers and their VDT use with musculoskeletal discomfort [Starr et al., 1982; Hunting et al., 1981; Läubli and Grandjean, 1984; Birch et al., 2000; Jensen et al., 2000; Forman et al., 1999, 2001, 2002; Thorn et al., 2002; Kadefors et al., 1999; Kitahara et al., 2000; Sjøgaard et al. 2000]. Recently, Gerr and colleagues conducted a prospective study of newly hired workers that documented musculoskeletal symptoms (MSS) and disorders (MSD). The study focused on the occurrence of MSD and MSS, to evaluate risk factors for both. Six hundred and thirty-two participants, who expected to use computers at work for at least 15 hours per week, were tracked for up to three years. The study assessed workstation dimensions and worker postures. During the study changes were noted of workstations. Medical evaluations were performed upon entry into the study, and during the study when subjects reported experiencing certain symptoms. The annual incidence of hand and arm (H/A) MSS was found to be 39 cases/100 person-years and of H/A MSD was 21 cases/100 person-years. The annual incidence of neck and shoulder (N/S) MSS was 58 cases/100 person-years and of N/S MSD was 35 cases/100 person-years. The researchers found that two or more years of previous computer use at 20 or more hours per week was associated with increased risks of developing hand and arm (H/A) symptoms and H/A disorders (Gerr et al., 2002). The amount of keyboard activity, in terms of hours per day, was associated with a slight increase in H/A symptoms and disorders. If the association is linear, a 20 hr/wk increase in keying would be associated with a 2.2 fold risk in H/A symptoms and disorders (Marcus et al., 2002). The most commonly diagnosed N/S disorder was "somatic pain syndrome", while the most commonly diagnosed H/A disorder was deQuervain's tendonitis. Muscle pain and tendonitis tend to be the most common diagnoses reported in epidemiological studies of VDT users (Hales et al., 1994; Gerr et al., 2002). Carpal tunnel syndrome is also known to be present in populations of VDT users (Tittiranonda et al., 1999). Among the major disabling workplace injuries and illnesses in 1999, carpal tunnel syndrome was associated with the highest median figure for days away from work (BLS 2001). Four percent of carpal tunnel syndrome cases and 9% of tendonitis cases reported in 1997 involved workers younger than 25 years old (BLS 2000).

In a cross-sectional study of newspaper employees, upper extremity disorders and work-related factors were evaluated through a survey of 973 participants. The number of hours spent under a deadline and reported hours of typing related significantly to musculoskeletal risks. Fifty-three percent of the employees reported spending 10 hours or more under a deadline, and this factor was a significant predictor of neck and hand/wrist MSD. The researchers implied that the increased risk could be associated with the deadline, creating increased psychological stress, increased musculoskeletal tension, a more constrained posture or fewer breaks being taken by the employees. Another major contributor was the hours reported typing. A dose-response relationship was identified. A two-fold increase in risk was determined for those who typed 6-8 hr/day, in comparison to those who typed 0-2 hr/day. An odds ratio of 3.3 was determined for those who typed more than 8 hr/day. This study also included a random sampling of the respondents to observe their actual typing hours. From the larger group, 76 workers were chosen. For those with hand wrist symptoms, the reported typing hours were 4.5 (standard deviation 2.6), while the actual observed typing hours were 2.5 (standard deviation 1.4). In the non-case referent group, the reported typing hours were 3.9 (standard deviation 2.1), but the actual observed typing hours were 1.9 (standard deviation 0.9) (Bernard et al., 1994). Although the workers tended to over-report their computing hours, the variation remained consistent between the two groups.

Some interventions in the office worker population have been shown to be effective in reducing VDT user discomfort (Tittiranonda et al., 1999; Aaras et al., 1998). In one intervention study of adult VDT workers, an introduction of a preset tilt down keyboard tray showed significant improvements in wrist posture, seated posture, and a reduction in upper body musculoskeletal discomfort, when compared with a control group that kept their current workstation setup (Hedge et al., 1995). In another study, incorporating rest breaks of 5 min every hour in addition to the conventional two-fifteen minute breaks was shown to reduce discomfort (Galinsky et al., 2000).

1.2.2 Children as Computer Users

An increasing number of studies are investigating children and their computer use. In one study involving children ages 10-17 years and their use of laptops, an extensive survey of 251 students was validated by individual observations and interviews of a group of 20 students (Harris and Straker 2000). Reported posture varied by location of the laptop use, and within the results, 60% of the students reported discomfort with using their laptop (Harris and Straker 2000). An association of discomfort was found with school grade levels, as well as time using the laptop. The average daily usage of these children's laptops was 3.2 hours, with a weekly average usage of 16.9 hours. In one sitting, the mean minimum time before a break was 11.5 minutes, but the maximum use time before a break averaged 101.9 minutes. There was a statistically significant association found between mean maximum time on task and discomfort while using the computer.

In a high school survey study of 382 students, 28% reported hand discomfort after using the computer, 40% reported neck/back pain, and 41% reported general body pain (Jones and Orr 1998). Of these students, 4% had been self-diagnosed or medically diagnosed with carpal tunnel syndrome, and 2.5% sought medical care for their pain. Jones and Orr further concluded that since high school students are establishing their lifestyle activities and patterns, the increased computer use at a younger age may increase the prevalence and trauma associated with computer use as students become older.

Another study emphasized the importance of educating students about MSD and teaching students about healthy computing. "Students are at risks for RSIs because of student behavior, laboratory arrangements, a lack of emphasis on posture in the curriculum, and the attitudes/perceptions of faculty and administrators" (Royster and Yearout 1999). In their study of students in grades 2-12, of those who experienced pain while using a computer, 67% did not stop, and 73% did not tell a parent. Computer literacy continues to receive a greater emphasis than ergonomics (Royster and Yearout 1999). The researchers stated that these characteristics of primary and secondary school students could easily be paralleled to all student populations. In their conclusion, Royster and Yearout urged three objectives: [the] revision of the current curriculum to include information concerning the potential [danger] of repetitive stress injuries and additional emphasis on postures; additional guidelines concerning computer workstation dimensions and laboratory set-up; and increased funding designated specifically for the purchase of ergonomic computer furniture.

In a study involving students in the 6th and 8th grades, five different mouse and keyboard configurations were offered, one including a keyboard and mouse tray with adjustable features (Laeser et al.,1998). The adjustable features configuration had a positive effect on posture, and the students most frequently chose this option as a more comfortable and easier set-up, demonstrating that intervention benefits may extend beyond adult computer users to child users, as well.

1.2.3 College Students as Computer Users

More people are considering college as a chance to further their education and expand on their career opportunities. In 1970, 8 million students were enrolled in post secondary institutions. The National Center for Education Statistics reported the fall enrollment in post-secondary institutions in 1999 to be over 14 million. With the projected enrollment numbers expected to be over 17 million in 2011, the student population steady growth will undoubtedly continue (Papadakis 2000).

A survey conducted in 1997 aimed at assessing the ergonomic knowledge of college students (Alexander 1997). The study asked yes/no questions in areas of general computer awareness, medical health and safety, radiation, computer workstation and environment, and computer workstation technique. Of the 254 responses, the best response rating was only 11 correct responses out of a possible 50. However, this survey was composed of "knowledge questions" versus assessment of the student's actions while using computers. Also, the terminology used by the survey may not have related well to student's computer use. For example the questionnaire used the term “worker” in some of the questions, and it is likely that most students do not think of their school as a work setting.

From San Francisco State University, a questionnaire investigating the possible association of computer use and discomfort received 95 student responses (Peper and Gibney 1999). The students reported an average daily computer usage of 2.9 hours, and nearly all students reported some level of discomfort associated with computing. Eighty-one percent of the students reported using techniques in order to 'feel better', such as stretching, taking breaks, and modifying their position or posture, but researchers speculated that these tasks were done only as a relief to discomfort and not as informed preventive measures. Students also reported extreme time pressure on some assignments, and the researchers felt that even if the computing activity on these assignments was short that stress could increase discomfort. However, no significant correlation between hours worked and reported discomfort could be found in this study. The researchers concluded that healthy computing programs for the employees at the University should be integrated into the student population as well (Peper and Gibney 1999).

More recently, one group of researchers studied college student computer users with more precision. The report by Katz et al. (2000), of a 1998 survey of senior undergraduates was the first article to report the prevalence of UE MSD in a population of college students. Ninety-six percent (1544) of the class completed the item on the survey referring to UE symptoms, “Do you experience pain, numbness, tingling or other discomfort in your hands, wrists or arms when you use a computer?”

> [From the responses,] 720 (47%) reported that they never had symptoms, 630 (41%) that they had symptoms after several hours of computer use, 106 (6.9%) that they had symptoms after computing for 1 hour or less, 49 (3.2%) that they had symptoms with virtually all activities.

Symptoms of UE MSD were associated with being female, a computer science concentration, and self-reported computing for more than 20 hours per week (Katz et al., 2000).

To identify how computers may affect college students, Katz and colleagues utilized focus groups and survey methods to learn more about undergraduate students who had experienced upper extremity symptoms (Katz et al., 2002). The goal of this research was to develop a student health-related role functioning measure, because the traditional Brigham Functional Limitations Scale task descriptions would not be as familiar to students (Katz et al., 2002). The 10-item list of student's tasks included five computer related items. One task of significant interest is the difficulty of typing 10 pages double-spaced on a computer. Results from their survey of 193 undergraduates showed the highest reported difficulty (36% prevalence) was with typing ten pages, while the prevalence of discomfort with other less stressful tasks ranged from 13-23%.

Another study by Katz's group investigated how Upper Extremity (UE) disorders affected graduate and undergraduate students (Cortés et al., 2002). The 16 symptomatic students were divided into two groups based on their class standing, and were guided by a moderator. The key questions aimed at their use of computers (time spent, breaks, etc), the risk factors for UE disorders, if they sought help with symptoms, their recommendations, and how having an UE disorder affected their lives and future goals. Overall, the students reported that computers have an essential role in academic, social, and personal lives. One of the participants described using a computer as early as age 5. Having an UE disorder had negative impacts on physical and emotional well being, including altering career aspirations to paths with less computer intensive obligations. Students' expectations and perceptions of medical care providers were overall negative. Most students reported that they were told to discontinue computer use, and students felt that this suggestion was not realistic. Students also reported a delay in seeking medical treatment because they did not feel their symptoms were serious enough, they were unsure of quality of medical care, or 'busy' with other parts of their lives. Of the two groups, graduate students in the study reported seeking medical care later than undergraduates. The groups' recommendations were for attention to early interventions instead of directing efforts toward those who already experience symptoms. The students believed information about RSIs needs to reach all students, and special emphasis needs to be made to ensure they understand the chronic nature if RSIs are left untreated. In addition, complete ergonomic evaluations of computer workstations should be performed, along with providing checklists of information in labs and example ergonomic adaptations of current workstations, along with ergonomic equipment in labs, for students to try out (Cortés et al., 2002).

Although it seems apparent that computer users are at risk of developing a MSD, skepticism of college students' risk, as compared with professional workers, remains. Some institutions are now requiring personal computers as a part of their enrollment. In those studies involving college students, few include a diverse population of graduate and undergraduate students. The usage patterns of college students are only quantified in general terms of weekly or daily computer usage. Computer use on specific days, such as during the week versus the weekend has not been described in available research; the days that college students use computers could vary depending on a variety of factors, such as academic concentration or class standing. Patterns of use throughout the day have not been described (use/break patterns). With only a few studies evaluating college students, the research need is clear; college students are the incoming work force. Compared to the current office worker, today's students started to use computers much earlier in their lives, and will continue to surpass the current typical office worker's lifetime usage by the time he/she is only midway through his/her career (Laeser et al., 1998).

Based on the existing relevant literature, an investigational model of student computer use and musculoskeletal discomfort was developed (see Figure 1.1). The first block partitions the sample of computer users into simple categories. When research has been conducted in the past on college students their class majors were considered. However, the differences between undergraduate and graduate students should also be considered further. In much of the previous research into MSDs and computer use, the personal factors of gender and age were investigated. Previous research that captured computer use profiles often simply asked for daily or weekly use. In this study the goal was to be more refined in the computer use profiles by considering the weekday use, weekend use and overall weekly use. In addition, the current study considered the time of day that the users worked on the computer. Finally, this model also examines patterns of continuous computer use (the time sitting in front of a computer before a break) as previous research has shown reduced discomfort with increased break frequency.

There is still much to be learned about college students' interaction with computers, their risk of developing MSDs, and means by which risk can be reduced. The rest of this document describes a study which was undertaken in order to expand the knowledge base in this area.

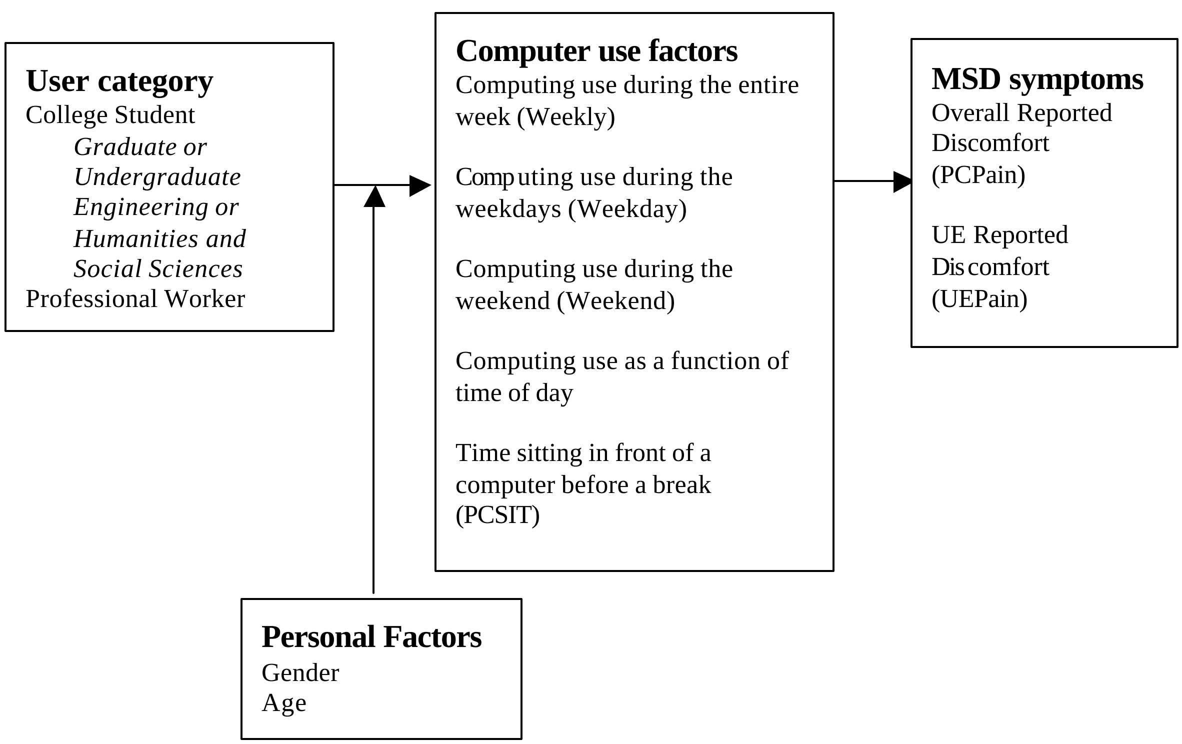

Figure 1.1: Graphical representation of thesis development.

1.3 Specific Aims

The aim of this study is to examine some musculoskeletal disorder risk factors associated with computer use in college students. The literature suggests the association between MSS and MSD and computer use may be affected by these factors: duration of computer use, frequency of computer use, and awkward postures (Bernard 1997). Therefore this study will evaluate these factors in college students. The results of this study will then be compared with the results of a previous survey of professional workers that has a similar question structure. In this comparison, if the students reported similar characteristics as the office worker, it will be concluded that they could be at potential similar risks for MSS or MSD.

The following hypothesis will be considered:

1) Graduate students will report a higher number of weekly computing hours than all other college student groups. Graduate students computing hours have not been compared before.

2) Graduate students will report more discomfort than their undergraduate counterparts. Graduate students reported discomfort has not been compared before.

3) Graduate engineering students will report a higher number of computing hours than all other class/ major combinations. Graduate students computing hours have not been compared before, but students' majors have been compared in previous research.

4) Women will have higher reported discomfort than men. This is consistent with studies involving adults, children, and college students.

5) College students’ use of computers from Monday through Friday will be less than worker's weekly reported hours. Evaluating computing hours during specific days of the week has not been done before.

6) College students' reported discomfort will be less than professional worker's reported discomfort. A reported discomfort comparison such as this has not been done before with college students.

7) College students reported upper extremity discomfort will be equal to office worker's reported upper extremity discomfort. A reported discomfort comparison such as this has not been done before with college students.

8) College students and professional workers who report less break frequency (sit for longer periods of time) will report more frequent overall discomfort. The reporting of sitting for periods of time and the comparison such as this has not been done before with college students.

The results of this study can be used toward increasing the emphasis on promoting healthy computing habits throughout all areas of education.

2 METHODOLOGY

The aim of this study was to investigate how college students use computers and compare their usage profiles with a previous study of professionals who use computers as a primary work tool. It is assumed that college students are preparing for professional careers, many, if not most, of which will require the use of computers. Since musculoskeletal discomfort and disorders are a concern for workers who use computers, it is appropriate to determine whether or not college students may be entering the workforce in a healthy state or entering with existing musculoskeletal problems that might be assumed to worsen or remain at a chronic level if they continue to use computers in their professional careers. Also, college students could be developing poor computing habits and some type of intervention incorporated into the university environment could be helpful to reduce the likelihood of poor computing habits.

2.1 Subjects

In Spring 2003 students from three universities, North Carolina State University, The Ohio State University and The University of South Florida, were invited to participate in the survey. The purpose of contacting multiple student bodies was to receive a broad view of student computer use. The data were collected as a convenience sample, and participants received no compensation for completing the survey. Participants were recruited in their classrooms, as they exited computer labs, and through word of mouth. The students were instructed of the voluntary nature of the study via the informed consent paragraph at the beginning of the survey. The North Carolina State University Review Board for the

Protection of Human Subjects in Research approved the study. Approximately 700 students, based on class rosters and the number of random codes generated in 23 classes were invited to participate in the study. Of those 700 students, 655 (93%) accepted or requested a survey access card. In a three-week period, 332 surveys were collected, of which 65 were discarded due to double entries. The remaining number of survey respondents was 267, for a response rate of 38%. Of those 267 responses, 33 were excluded for various reasons, described below, leaving a total of 234 responses that were included in the analyses.

2.2 Survey Instruments

A survey was developed in this current study based on previous research of professional office-based workers (Sommerich 2002). Each of these surveys is further described below and a copy of the student survey is included in Appendix C.

2.2.1 Professional Office Worker Survey

This comprehensive survey instrument (Sommerich, 2002) included a total of 6 sections and 280 questions. The survey was divided into sections so that participants could take portions of the survey at different times. If participants only used one computer configuration for work, either a desktop or notebook/laptop only, then they would only respond to 5 out of 6 sections. Part 1 (estimated completion time: 10-15 min) was directed at desktop computer users and participants were instructed to complete this part "only if you use a desktop computer for work at least 8 hours/month, on average". Part 2 (estimated completion time: 15-20 min) was directed at notebook computer users and participants were instructed to complete this part “only if you use a notebook computer for work at least 8 hours/month, on average”. All participants answered the remaining sections. Part 3 included more general questions about work (estimated completion time: 15-20 min). Part 4 included questions about health (estimated completion time: 10-15 min). Part 5 included questions about the participant’s activities outside of work, and some demographic information (estimated completion time: 15-20 min). The last section was a completion confirmation to ensure that all sections were answered (estimated completion time: 1-2 min). This survey instrument was much more detailed than the shortened college student instrument described next. The specific questions derived from this survey instrument and included in the college student study are included in Appendix D.

2.2.2 Current Survey

The 19-item web-based survey instrument was divided into four sections (See Appendix C). The survey's maximum completion time was estimated to be no longer than 20 minutes. The first section was the input of the access code. An access code was given to interested students, which was a unique random number, generated for the purpose of preventing double entries. Out of 267 responses, 11 responses did not have the code, and so their responses were not used in the analysis.

Along with an access code, there was an informed consent paragraph in the subsequent section. The informed consent stated that this survey would ask questions about their computer use, that it was voluntary and that they were not obligated to answer any of the questions if they agreed to participate. The participants had to check "yes" to indicate that they had read this paragraph and understood what they were being asked to do for this study. Out of 267 responses, 15 responses did not have this box checked, and so their responses were not used in the analysis

The third section of the questionnaire inquired about the student's computer use. These questions were a subset of questions from the professional worker study. They were selected to focus on computer use in relation to location, duration, frequency, posture, and discomfort. Some questions were tailored to suit a student's usage. For example, for the locations of computer use, the list of possible responses included such locales as home, campus home, computer lab, library and an open-ended response. Computing habits queried included computer use measured in hours per day, software application usage, and typical computing time frames during each day, selected from a table of two-hour time divisions. Periods of computer use before taking a break were estimated by having students answer how often they sit continuously while using the computer: *Never, Rarely, Sometimes, Quite often or Almost always*, in 30 minute intervals from 30 minutes up to a total of 120 minutes. Section Four included student characteristics, year born, gender, and other demographic information for general population comparison, and the accompanying questions such as class standing, major, and when they started using computers, for internal comparisons. The instrument has a 7.8 grade level readability as measured by the Flesch-Kincaid readability scale [Microsoft Office 2000].

2.3 Processing of Student Data

2.3.1 Data Filtering

Categories of class major and class standing were condensed. To provide a clearer picture of groups, and limit the variability of response, class majors were condensed to either Engineering or Humanities and Social Sciences. All other responses that did not fit into these categories, only seven participants, were dropped from the data set. Class standing was condensed from freshman, sophomore, junior, senior, or graduate student to either an undergraduate student or graduate student.

2.3.2 Data Transformation

Due to the variability and flexibility of responses in some questions, some data cleansing and processing was required prior to analysis. Any blanks were changed to "." to denote a missing response for ease of data analysis. Any obvious incorrect responses were salvaged or deleted. For an example of an incorrect and unsalvageable response, one subject indicated using a computer 30 hours in a single day. Obviously incorrect responses that could not be salvaged were deleted and replaced with a blank, indicated by a ".".

There are two questions, about location and software applications, that allow for an 'other' response to be specified. Most of the ‘other’ responses were categorized and condensed. For example, an added response of work was included, but types of 'other' responses included: work, job, office/cubicle, internship, etc.

Questions that required typed responses did not have limiting programming to ensure a proper response, and some responses did not follow the format of the question. In the question requesting ‘year born’ some respondents wrote a city or place instead of a year; these types of answers were deleted, then changed to blanks, denoted as a ".". In another such example, a respondent stated in the year born question, 'for question 3.10 my fingers hurt almost always; 1979'. Since question 3.10 was referring to discomfort, this response was changed to ‘hands, Almost always’, with the year born response limited to only "1979".

Descriptive data were also minimized to reduce coding. The female and male gender was simplified to female = 1 and male = 2. In other questions where only one response was possible, either the participant indicated that they used a particular software program or not, the response was changed to a "1" if the software was indicated and a "." if the software was not indicated. In questions with scaled responses, such as *Not likely*, *Somewhat likely*, *Pretty likely* and *Very likely*, the responses were recorded as these specific phrases. In processing the responses, the phrases were changed to numeric quantities, 1-4, with 4 being *Very likely*, to increase ease of use in the statistical analysis program (SAS, Cary, NC). Another scale included descriptors which were also changed to numeric values; they are: *Never* = 1, *Rarely*=2, *Sometimes*=3, *Quite often*=4, *Almost always*=5.

In estimating hours worked per day on the computer, some respondents chose to provide a range of hours instead of a single estimate. In processing responses, all hour input per day and per type of computer responses (desktop or laptop/notebook) were changed from the respondent's single value or range of values to one of three answers: a minimum, an average, and a maximum value. For those subjects who gave a single hour quantity, the value was maintained in the average column. For those who provided a range, the average was calculated as the center point of that range. For calculating comparisons of computing hours, the average value was utilized. For weekly computing hours, all averages for each day were summed and referred to as the variable 'Week'. For weekday computing hours only the average hours of Monday thru Friday were summed and referred to as the variable 'Weekday', and the variable 'Weekend' was the summed average computing hours for Saturday and Sunday.

For the question, how likely are you to sit continuously for X amount of time before taking a break, with increment breaks of 30, 60, 90, 120 minutes, a new variable was created. A weighted average of the four individual sitting descriptions was calculated using this formula: [("...for more than 30 minutes "*1)+("...for more than 60 minutes" *2)+("...for more than 90 minutes"*3)+("...for more than 120 minutes"*4)]/10. The longer the sitting postures, the higher the weighting factor. A score was marked as a missing value for subjects who did not provide responses for one or more of the questions in this set. This variable was referred to as PCSITSCR, and was compared with other variables and within the different groups to determine any correlation with discomfort (Sommerich 2002).

For characterizing frequent discomfort specifically associated with use of a computer, the number of times a subject reported a discomfort of *Quite often* or *Almost always* was counted and summed from each of the body areas (Sommerich 2002). This was labeled as the subject's PCPain score. Frequent discomfort in the upper extremity (right forearm or elbow, left forearm or elbow, right shoulder, left shoulder, neck, upper back) was also computed, referred to as the variable UEPain.

2.4 Data Processing for Comparing College Students with Professional Workers

2.4.1 Data Transformation

Some questions were asked in more detail than others between the surveys and therefore processing steps were required. The format of the professional workers survey was more extensive than the college student study. If the participant indicated using both a desktop and laptop/notebook computer configuration there were more questions involving details of the configurations that were different for each type of computer. Therefore the difficulty of combining responses on these questions to compare to the less detailed college student survey posed a considerable challenge in data processing. Therefore from the professional worker study, only those participants were included who used only one type of computer configuration.

In the question regarding prior computer usage, the student question was worded differently from the professional worker study, and also provided different response options. The students were given an answer selection set of high school, middle school, grade school, home, none, and not sure. In the professional worker study, the participants entered the year they started using a computer. To compare these groups, the start age was calculated as the difference between the year started using a computer and the year born. From that, estimates were made of the grade level. Those who began using computers before the age of 18 were characterized as using computers in high school, those before the age of 13, middle school, before the age of 11, grade school. Then, the data were manipulated into a numeric range, high school = 4, middle school =5, and grade school =6. The responses of "None" or "Not sure" or "Home" were not readily comparable to the office workers, but were summarized for descriptive statistics.

Another question worded differently was the numerical value input of computing hours per day. The office workers only entered a value representing average hours in a workday they worked on a computer for their job, which will be assumed as 5 days a week. Another question indicated a value for hours per week spent using a computer for purposes other than their professional employment. For a weekly computer usage comparison to the college students, the average workday usage was multiplied by five and added to the hours working on a computer that did not pertain to the job, as a rough estimate of average weekly computing.

In the comparison of college students and professional office workers, the age span differences could yield skewed results in their comparison. Therefore in the formal statistical analysis, an age adjustment was completed. All those participants 35 years and over were dropped from the data set during the comparison of college students and professional workers in the formal statistical analysis.

2.5 Experimental Design

2.5.1 Independent Variables

2.5.1.1 Independent Variables within the College Student Study

The independent variables in this study were the class standing (referred to as 'Class' in the analysis) and college major ('Major') of the respondents. This divided the participants into four categories of undergraduate or graduate student and the colleges of Engineering or Humanities and Social Sciences (Table 2.1). Also considered were potential gender differences ('Gender'). The interaction between the variables class standing and college major was also considered in the data analysis to investigate one of the hypotheses. Other second order interactions were not considered.

Table 2.1: Distribution of subjects by class standing and college major.

	Engineering	Humanities & Social Sciences
Undergraduate	76	64
Graduate	49	45

2.5.1.2 Independent Variables used in the Comparison of the College Students and Professional Office-Based Workers

When the two studies were compared, the independent variables were the classification of the respondent, either a college student (CS) or a working professional (WP). The college student or professional worker classification is referred to as the 'Category' variable in the analysis. Also considered in comparisons were gender differences ('Gender').

2.5.2 Dependent Variables

The dependent variables of interest were based on questions that inquired about the participants' computer use in the areas of frequency, duration, posture, discomfort, demographic information, and previous computing experience. Some of these responses were evaluated qualitatively in descriptive statistics while others were formally addressed in a statistical analysis.

2.5.2.1 Dependent Variables for Descriptive Characteristics

Some types of questions could indicate multiple responses with check boxes. Examples of the questions utilized in the descriptive statistics included types of computer configurations, software applications, locations of computer use, and race/ethnic origin. Simply tallied, these results were presented as percentages of participants that indicated these responses.

The frequency of computer usage was addressed through several scaled response questions. First, how often the participant used a computer in a typical week included responses of *Never, At least once during the week, Most days, Every day*. A second question asked how likely they are to use the computer on each day and how likely they are to use the computer during specific two-hour time periods throughout the day. The descriptive responses included: *Not likely, Somewhat likely, Pretty likely or Very likely*. Both of these questions were identical in formatting in both studies and would yield comparison of use patterns between the college students and working professionals.

Another important aspect of computing is working in a healthy or "neutral" posture. Posture information was made available through the following question about awkward posture. Participants were asked if "When using the computer, I find myself assuming awkward, uncomfortable or "poor" postures?", and the descriptive responses available included: *Never, Rarely, Sometimes, Quite often, Almost always*. College students were able to indicate separately for each computer configuration type, whereas professional workers indicated for only their workplace computer configuration, either a desktop or notebook/laptop computer.

2.5.2.2 Dependent Variables for Formal Statistical Analysis

Statistical analysis was performed on the quantitative value of average hourly computer usage during a particular day in an average week. The college student's raw survey data listed a number of hours for each day on either a desktop or notebook unit, in either a range or discrete quantity. The discrete quantity was considered the average, and if a range was provided, an average of the values was determined. Summations were completed for a weekly total ('Weekly'), a weekday total (Monday through Friday) ('Weekday') and a weekend total (Saturday and Sunday) ('Weekend'). The weekly totals were the only ones considered in the comparison of college student and professional workers.

Descriptive information about duration of computer use could also be determined from questions utilized in both studies. The derivation of the composite variable ('PCSITSCR)' is defined Section 2.3.2. Reported frequent discomfort ('PCPain') is a summation of discomfort throughout the body and its derivation is shown in Section 2.3.2. Reported frequent upper extremity discomfort ('UEPain') is a summation of discomfort in the parts making up the UE and its derivation is shown in Section 2.3.2.

2.6 Statistical Data Analysis

The survey consisted of both ratio and ordinal data. JMP (Version 4.0.4, SAS in Cary, NC) was used for analysis. Throughout the analysis, a probability of less than .05 indicated a significant effect. The data of reported computing hours were analyzed through a one-way analysis of variance (ANOVA).

Before beginning the ANOVA analysis the basic assumptions of the technique were evaluated. ANOVA assumes that the residuals are from a normal distribution, therefore the residuals of the response variables were tested for normality, using the Shapiro-Wilk test. The Shapiro-Wilk test detects departures from normality of the hypothesized normal distribution without requiring that the mean or variance be known (JMP). Small values of W are evidence of departure from normality. If the Shapiro-Wilk value is 1.0, then the distribution is perfectly normal. Another ANOVA assumption is that the variances are homogeneous; therefore the residuals and predicted values (fitted values) were plotted. The residuals were then evaluated graphically as put forth by Montgomery (2000)

The ANOVA procedure was used to evaluate the effects of the independent variables on the computing hours. Within the college student study, the effects of the student's class standing, major, gender and the interaction between class and major were evaluated against the responses of reported weekly, weekday and weekend computing. Comparisons were also made between the professional workers and the students, to determine the effects on the response of weekly reported computing hours. The data set used to test these effects was the data set that eliminated those respondents over 35 years of age.

As most of the survey was subjective and can be classified as ordinal scales, a nonparametric ANOVA was performed. Namely, the Wald Chi-Squared test was used for the analysis that tested the effects of the independent variables on PCPain, UEPain and PCSITSCR. Significant probabilities are those of .05 or less and are often considered evidence that the distributions across factor levels are not centered at the same location. The Wald Chi-Squared test results were confirmed by the Kruskal-Wallis test statistic used to determine the coincidence of the variance means. If the Kruskal-Wallis $\div^2$ value is small in the table, the means are not coincident; therefore the differences are not statistically significant. A p-value of less than .05 denotes statistical significance of the $\div^2$ value. Again, for those tests that compared the college students to the professional workers the data set used to test the effects of the independent variables was the data set that eliminated those respondents over 35 years of age.

Finally a correlation analysis was also performed to investigate the relationship between PCSITSCR and PCPain. This analysis was performed on the college student data set as well as the truncated data set (<35 years old) of both college students and professional workers.

3 RESULTS

3.1 Description of College Students and Professional Workers

3.1.1 College Students and Professional Workers Demographics

The professional worker's mean age differed from the college students by 18.8 years. The majority of the participants in both studies were Caucasian (Table 3.1). Interestingly, 20% (48) of students reported the use of computers in grade school, 24% (56) in middle school and 40% (92) in high school. In comparison, 3% (11) of workers reported first use of computers at a grade school age, 3% (10) middle school and 22% (67) at high school age.

Table 3.1: Demographic information for the two samples: age, gender, and race/ethnicity.

	College Students n=234	N for CS question	Professional Workers n=302	N for PW question
Mean age, years (sd)	25.2 (6.4)	219	44.4 (9.9)	300
Gender, n (%)	87 Males (37.2%) 147 Females (62.8%)	234	181 Males (60.5%) 118 Females (39.4%)	299
Race/ethnicity, n (%)	179 Caucasian (76%) 31 Asian (13%) 27 Other (11%)	232	272 Caucasian (90%) 8 Asian (3%) 23 Other (7%)	297

3.1.2 Computer Configurations, Location and Applications Usage

3.1.2.1 College Students

The types of computer used by students were varied, with 102 students reporting use of both desktop and notebook/laptop configurations. The number of students to only use the desktop configuration was similar to students who used both, the number was 122, but the number of students only using notebook/laptop configurations was much lower, at 10 students.

Eighty-nine percent (210) of the students reported using a computer at "Home (your permanent address)". Computer labs followed closely at 77% (182). Lower percentages were reported at the "Home (campus address, if different) and Campus Home" 56% (132), the library 35% (83), and other 33% (77). The most frequently listed 'other' category was work; 67 students specified using the computer at work (26%).

Every participant indicated using at least one software application. Nearly every student reported using the World Wide Web (99%, n=233), word processing (99%, n=232), and email (98%, n=231). A high percentage of students also indicated use of spreadsheet (79%, n=185) and presentation (74%, n=173) applications. Less than 45% of the students reported using each of the other applications on the list: program development, CAD/CAM, web design, graphics, time management, voice recognition, database, company intranet, simulation, data analysis, and 'other'.

3.1.2.2 Professional Workers

From the professional worker study, those participants were included who used only one type of computer configuration. The percentage of desktop users was 31% (95) and notebook users 68% (207). The location options were different for professional workers and not comparable to the student survey.

Professional Workers tended to have similar application use as the students. Professional workers reported using email applications the most; at 99% nearly every participant indicated the use of this software. Other commonly used applications were the World Wide Web (98%, n=297), word processing (97%, n=293), spreadsheets (83%, n=253) and presentations (76%, n=232) software. Additionally, 92% of the professional workers reported using the company intranet. Each of the other applications that appeared on the list was used by 57% or less of the worker sample.

3.1.3 Computer Usage Trends

3.1.3.1 College Students

All students reported using a computer at least "most days", with the majority of students (91%) reporting that they used a computer every day in a typical week. The likelihood of using the computer on any day during the week followed similar trends. The highest number of students, at least 50% during the weekends and over 80% during the week, indicated that it was *very likely* that they would use a computer on those days (Figure 3.1).

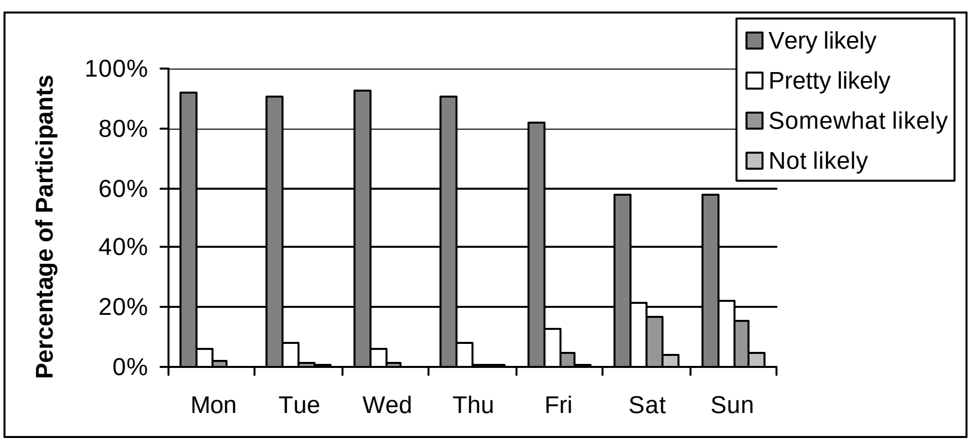

Figure 3.1: Likelihood of college student computer use throughout the week.

3.1.3.2 Comparison of Student and Professional Worker Computer Usage Trends

Both groups were asked about the likelihood of using a computer during specific time periods. The time periods illustrate a different pattern of reported computer use between students and professional workers as shown in the highest level of response, 'Very likely' (Figure 3.2).

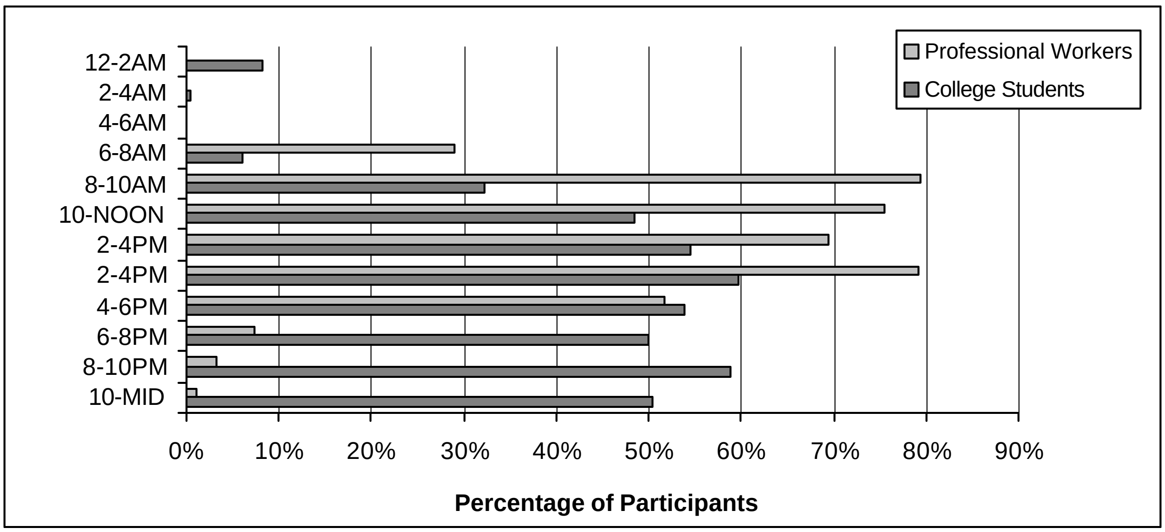

Figure 3.2: Percentage of participants who were "Very Likely" to use the computer at specific intervals during the day.

This pattern also continues in the summation of the responses, but to a lesser degree (Figure 3.3). The professional workers appear to concentrate their computer use during the normal business hours, while the college students computing hours shift towards the evening hours. This graph tends to show that, as a group, college students may have a shorter recovery period (2:00 a.m. – 8:00 a.m.) between computing hours than the professional workers (6:00 p.m. – 6:00 a.m.).

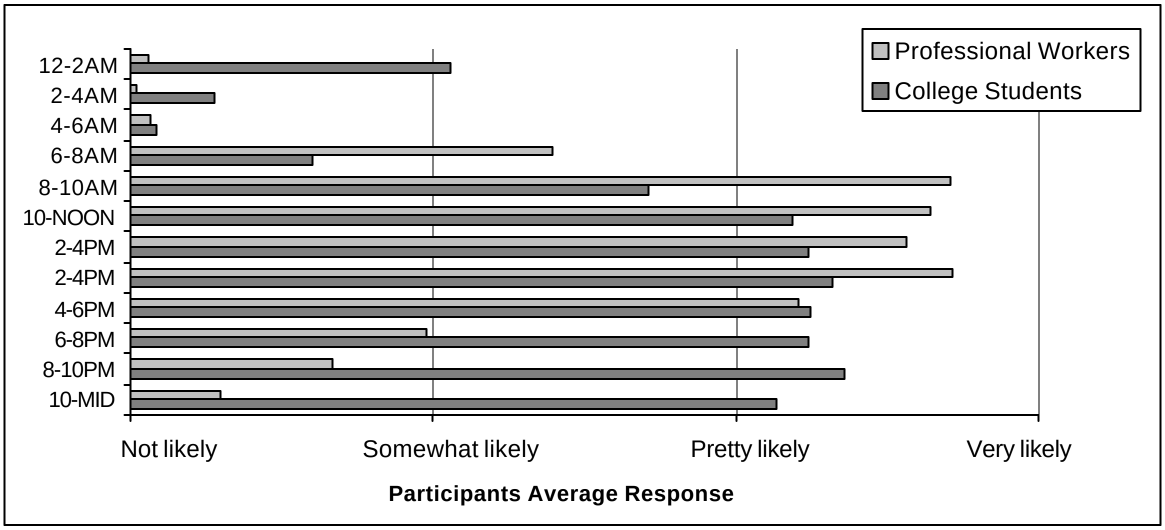

Figure 3.3: Average computer use likelihood during the day.

3.1.4 Comparison of Reported Computing Posture

College students and professional office workers both responded to a similar question, "When using the computer, I find myself assuming awkward, uncomfortable or "poor" postures?". The responses of the college students (Figure 3.4) and professional workers (Figure 3.5) show somewhat different responses with the professional workers distribution centered on "sometimes" and the college student distribution shifted to lower frequency levels. This was the general response regardless of whether the participants were describing their awkward postures using a desktop or notebook computer.

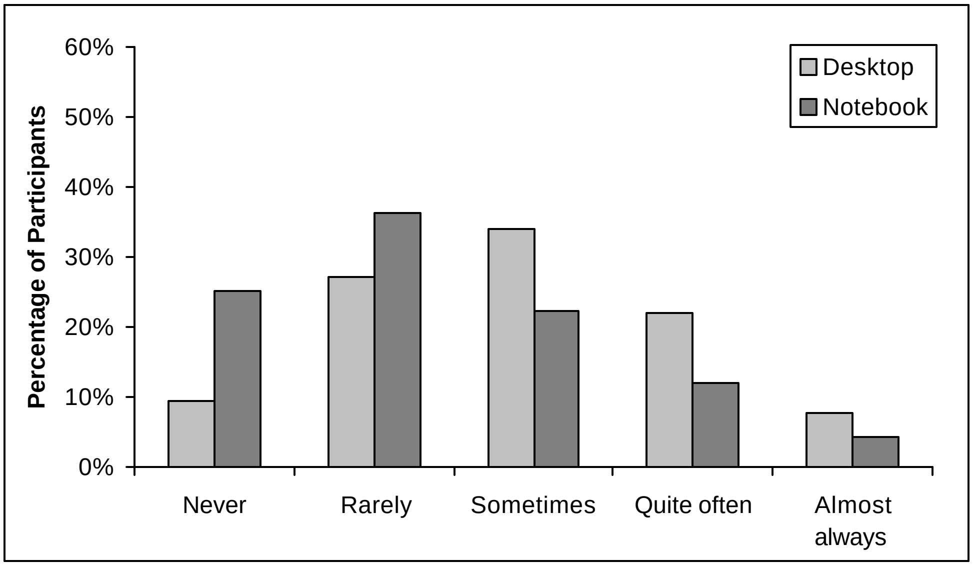

Figure 3.4: College students' awkward posture response.

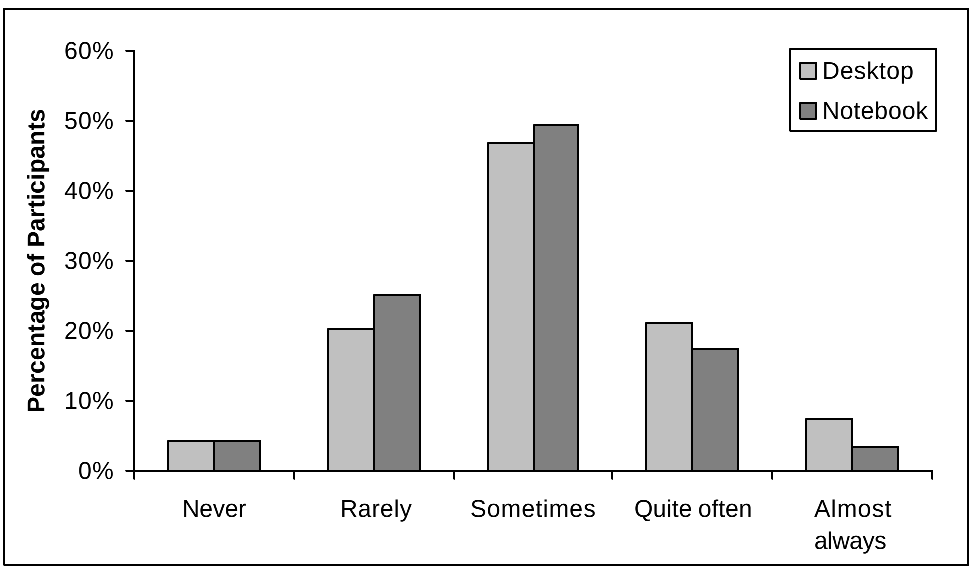

Figure 3.5: Professional workers' awkward posture response.

3.2 Assumptions of ANOVA

The normal distribution assumption of the residuals was determined from the Shapiro-Wilk test and a graphical analysis (Table 3.2). The Shapiro-Wilk test showed significant departures from normality for the residuals, but the subsequent graphical analysis (Appendix

A) showed this to be the result of the skewness of the distribution. This, in conjunction with the robustness of the ANOVA procedure to moderate departure from normality, satisfied the concern regarding the normality assumption (Montgomery 2000). The plot of residuals versus the predicted values did not show trends and therefore the assumption of homogeneity of variance is upheld (Appendix B).

Table 3.2: Goodness of Fit Shapiro-Wilk W Test

Category	Dependent Variable	W	Prob<W
College Students	Weekend Computer Use	0.923636	<.0001
	Weekday Computer Use	0.935168	<.0001
	Weekly Computer Use	0.9391	<.0001
Comparison of College Students and Professional Workers	Weekly Computer Use	0.948684	<.0001

3.2.1 College Students' Major, and Class Standing Divisions

For this study, the college students were compared within their major and their class standing (Refer to Table 2.1). Within class, undergraduates tend to be of a specific age group while graduate students are more diverse. In both colleges, undergraduates were concentrated mainly in the 20-24 year age range (Figures 3.6 and 3.7).

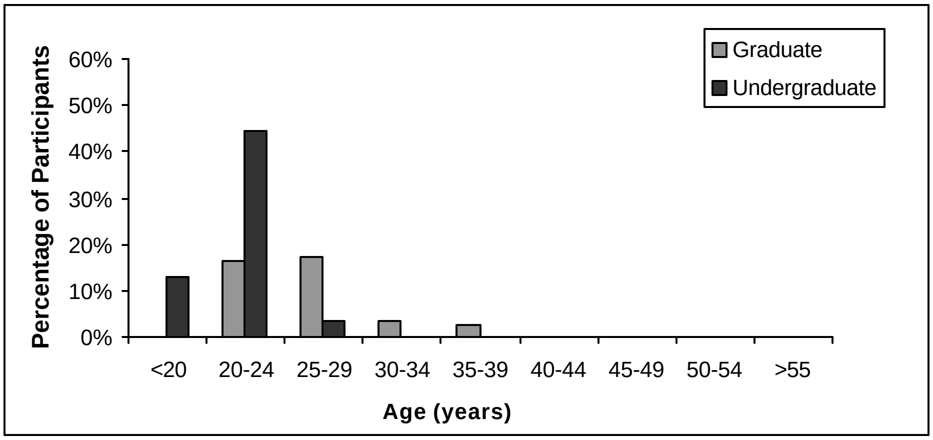

Figure 3.6: Age distribution of engineering college students within class standing.

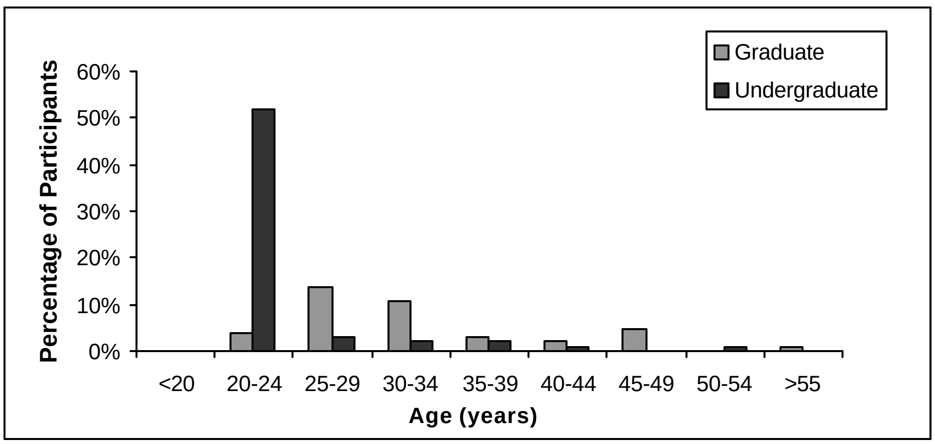

Figure 3.7: Age distribution of humanities and social science college students within class standing.

3.2.2 College Students' Weekday Computer Use

When comparing the weekday computer use within the student populations, only Class had a significant effect, with weekday use being greater for the graduate students than for the undergraduates (Table 3.3 and Figure 3.8). The average reported weekday computing hours for graduate students was 25.3 (s.d. 12.8), and the average reported weekday computing hours for undergraduates was 20.4 (s.d. 10.9).

The figure is a Means Diamonds plot, which illustrates the group means, 95% confidence interval, overlaps marks to visualize significance, and proportional sample sizes. The middle line in the diamond is the mean. The tips of the diamond indicate the 95% confidence interval. The width of each diamond spans the distance on the horizontal axis proportional to the group size. The other lines in the diamond are the significance overlap lines. For groups with equal sample sizes, the marks that appear to overlap indicate that two group means are not significantly different at the 95% confidence interval. The dashed line in the graph is the overall average weekday computing hours of both the graduates and undergraduates combined.

Table 3.3: ANOVA results for college students' weekday computing hours.

Source	Sum of Squares	F Ratio	Prob > F
Class	**1313.1693**	**9.5693**	**0.0022**
Major	80.243	0.5847	0.4452
Gender	5.906	0.043	0.8358
Class*Major	2.5769	0.0188	0.8911

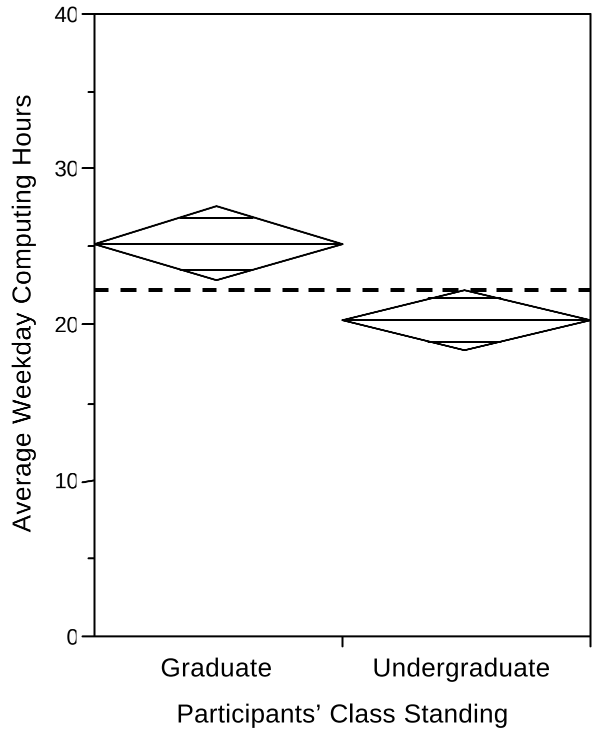

Figure 3.8: College students' weekday computer use by class standing

3.2.3 College Students' Weekend Computer Use

When comparing the weekend computer use within the student populations, only Class had a significant effect, with weekend use being greater for the graduate students than for the undergraduates (Table 3.4 and Figure 3.9). The average reported weekend computing hours for graduate students was 7.6 (s.d. 5.5), and the average reported weekend computing hours for undergraduates was 6.2 (s.d. 4.1).

Table 3.4: ANOVA results for college students' weekend computing hours.

Source	Sum of Squares	F Ratio	Prob > F
Class	**115.18756**	**5.2527**	**0.0228**
Major	43.74887	1.995	0.1592
Gender	7.47172	0.3407	0.56
Class*Major	49.47442	2.2561	0.1345

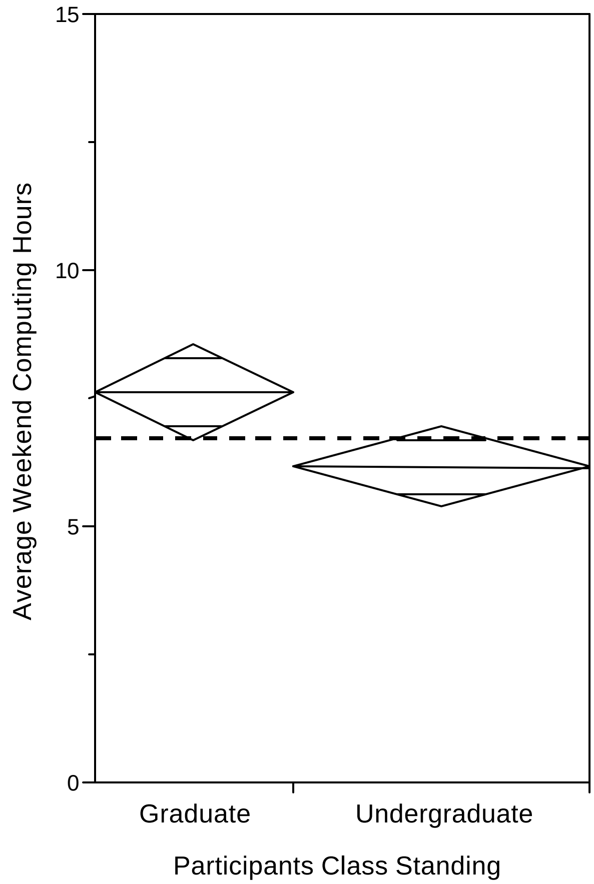

Figure 3.9: College students' weekend computer use by class standing.

3.2.4 College Students' Weekly Computer Use

When comparing the weekly computer use within the student populations, only Class had a significant effect, with weekly use being greater for the graduate students than for the undergraduates (Table 3.5 and Figure 3.10). The average reported weekly computing hours for graduate students was 32.9 (s.d. 16.4), and the average reported weekly computing hours for undergraduates was 26.6 (s.d. 14.0).

Table 3.5: ANOVA results for college students' weekly computing hours.

Source	Sum of Squares	F Ratio	Prob > F
Class	**2206.2019**	**9.7022**	**0.0021**
Major	5.4923	0.0242	0.8766
Gender	0.0919	0.0004	0.984
Class*Major	29.4691	0.1296	0.7192

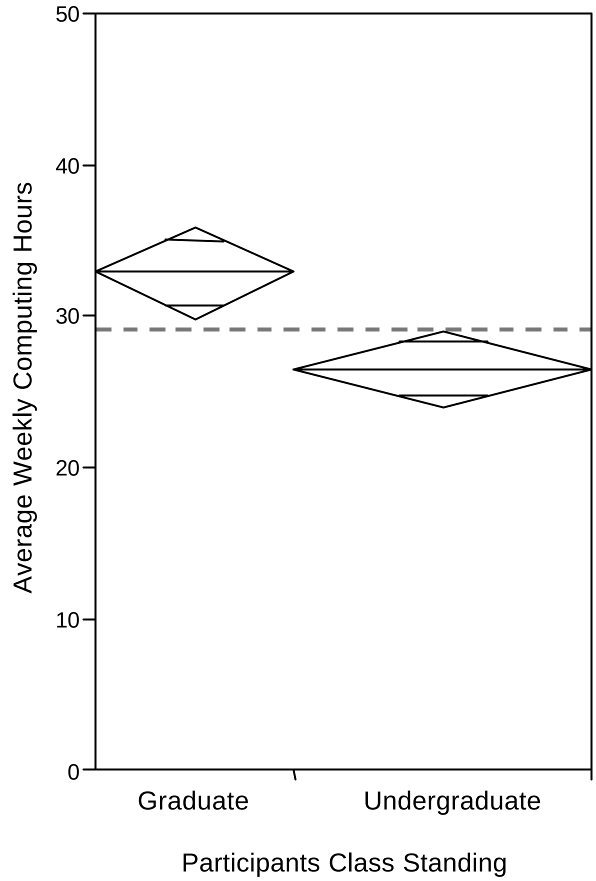

Figure 3.10: College students' weekly computer use by class standing.

3.2.5 Results from Non-Parametric Tests

Table 3.6 is a summary of the Kruskal-Wallis test results to confirm the Wald Chi-Squared test on the non-parametric data. A p-value of less than .05 denotes statistical significance of the $\div^2$ value (Table 3.7).

Table 3.6: Results from the Kruskal-Wallis Test (One-Way Analyses) for college students.

Dependent Variables	**Independent Variables**	$\div^2$	**Pr>** $\div^2$
PCPain	Class	1.1162	0.2907
	Major	3.1801	0.0745
	Gender	**12.4491**	**0.0004**
UEPain	Class	0.7197	0.3962
	Major	3.2907	0.0697
	Gender	**11.8141**	**0.0006**
PCSITSCR	**Class**	**13.4666**	**0.0002**
	Major	0.0269	0.8698
	Gender	3.7252	0.0536

3.2.5.1 Overall Reported Frequent Discomfort (PCPain variable)

When comparing the total reported frequent discomfort associated with computer use within the student populations, only Gender had a significant effect, with total reported frequent discomfort scores being greater for the females than for the males (Table 3.7 and Figure 3.11).

Table 3.7: Wald Chi-Squared results for college students' PCPain.

Source	Nparm	DF	Wald ChiSquare	Prob>ChiSq
Gender	**1**	**1**	**8.71542055**	**0.0032**
Class	1	1	1.17114175	0.2792
Major	1	1	0.34840201	0.555
Class*Major	1	1	0.2620278	0.6087

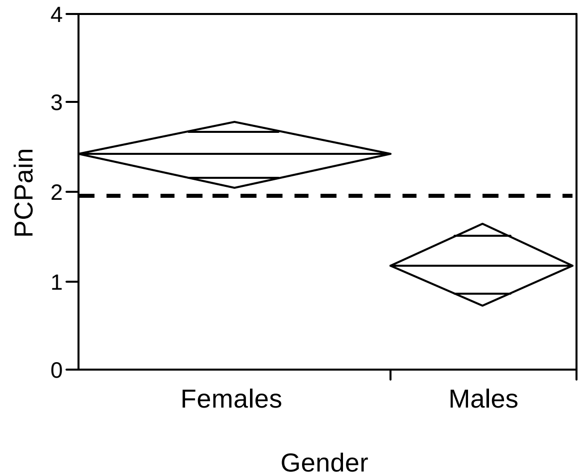

Figure 3.11: College students' reported discomfort by gender.

3.2.5.2 Upper Extremity Reported Frequent Discomfort

When comparing the total reported frequent UE discomfort associated with computer use (UEPain) within the student population, only Gender had a significant effect, with total reported frequent UE discomfort scores being greater for the females than for the males (Table 3.8 and Figure 3.12).

Table 3.8: Wald Chi-Squared results for college students' UEPain.

Source	Nparm	DF	Wald ChiSquare	Prob>ChiSq
Gender	**1**	**1**	**8.17873193**	**0.0042**
Class	1	1	0.73317852	0.3919
Major	1	1	0.40852425	0.5227
Class*Major	1	1	0.23921923	0.6248

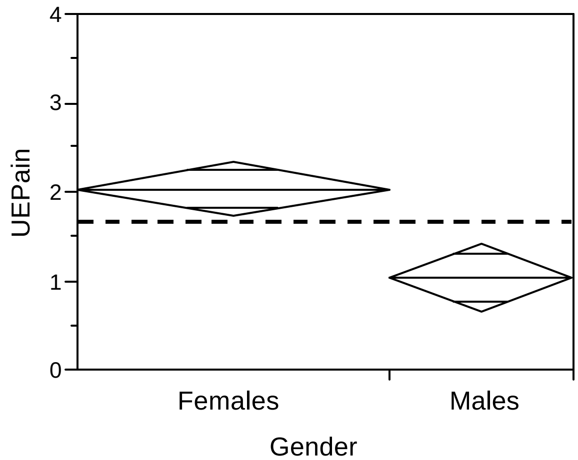

Figure 3.12: College students' reported upper extremity discomfort by gender.

3.2.5.3 Composite Score of Time Sitting While Using the Computer Before Break

When comparing the weighted time between breaks of 30, 60, 90, and 120 minutes (PCSITSCR), within the student population, only Class had a significant effect, with the time between breaks being greater for the graduate students than for the undergraduates (Table 3.9 and Figure 3.13).

Table 3.9: Wald Chi-Squared results for college students' PCSITSCR.

Source	Nparm	DF	Wald ChiSquare	Prob>ChiSq
Gender	1	1	3.01666785	0.0824
Class	**1**	**1**	**12.7621049**	**0.0004**
Major	1	1	0.56407564	0.4526
Class*Major	1	1	0.01261326	0.9106

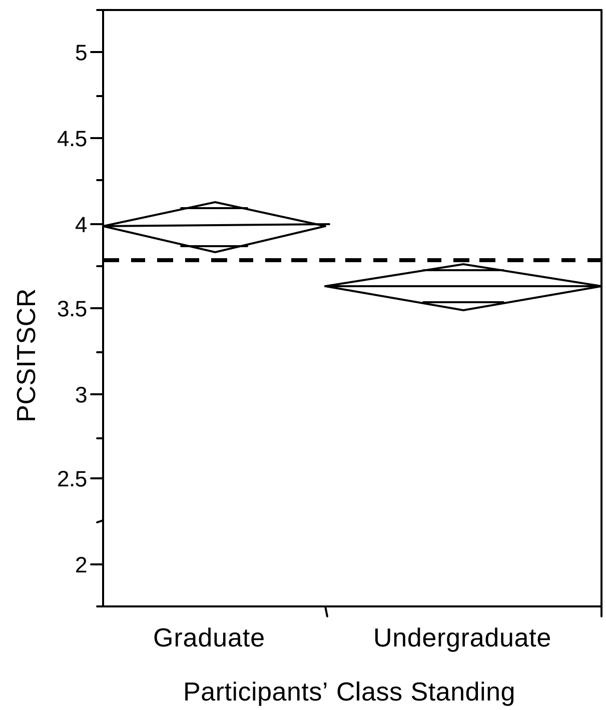

Figure 3.13: College students' PCSITSCR by class standing.

3.2.6 Correlation between Discomfort and Composite Score of Time Sitting for College Students

The correlation between the reported discomfort (PCPain) and likelihood of continuously sitting was 0.35 ($p<.0001$), suggesting a relationship between static positioning and discomfort (Figure 3.14).

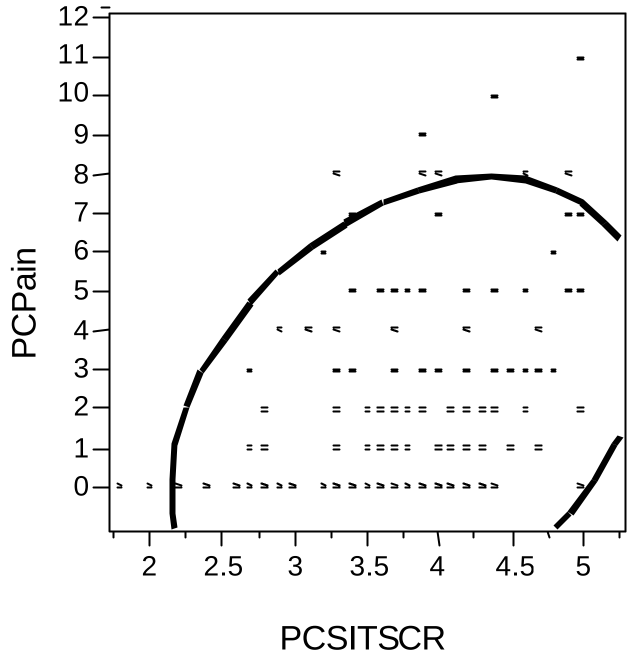

Figure 3.14: Correlation between PCSITSCR and PCPain for college students.

3.3 Comparisons between College Students and Professional Workers

3.3.1 Age Distribution between College Students and Professional Workers

A considerable average age difference of 18.8 years existed between participants in the two studies. The variation in the age span of the two groups could lead to skewed results in their comparison; therefore as described in the methodology, all those participants age 35 and over were dropped from the data set for the comparisons presented in this section (Section 3.4). This age cutoff reduced the average age difference from 18.8 years to less than 7 years (Figure 3.15).

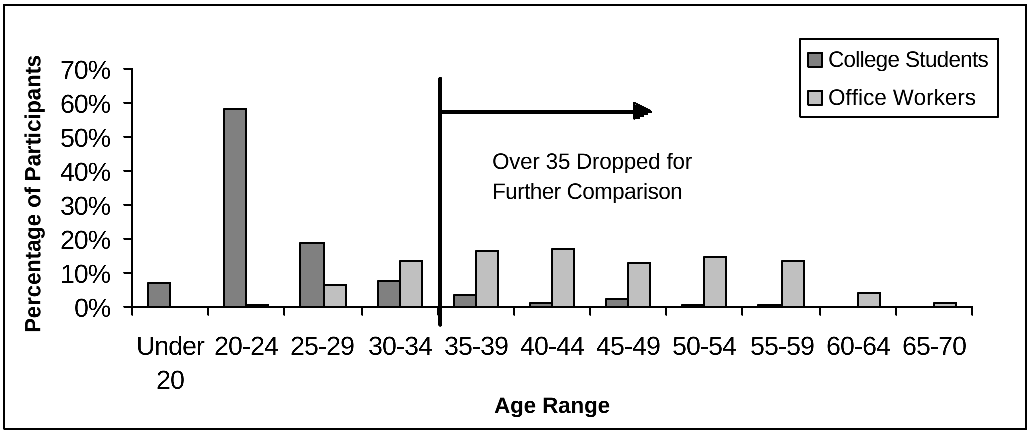

Figure 3.15: Participants' age distribution and those excluded for further comparison.

3.3.1.1 College Students

The remaining 201 students of the original 234 had a mean age of 23.6 years (s.d. 3.6), and there were 121 females and 80 males. The distribution of class standing and college major changes after the elimination of those over 35 years of age (Table 3.10).

Table 3.10: Distribution of subjects by class standing and college major for college student participants under age 35.

	Engineering	Humanities & Social Sciences
Undergraduate	43	29
Graduate	71	58

3.3.1.2 Professional Workers

The remaining 60 professional workers of the original 302 had a mean age of 30.5 years (s.d. 2.9), and there were 30 females and 30 males.

3.3.2 College Students' and Professional Workers' Weekly Computer Use

When comparing the weekly computer use between the college students and professional workers, only Category (CS or PW) had a significant effect, with weekly use being greater for the professional workers than for the college students (Table 3.11 and Figure 3.16). The average reported weekly computing hours for professional workers was 35.1 (s.d. 12.6), and the average reported weekly computing hours for college students was 29.1 (s.d. 15.6).

Table 3.11: ANOVA results for college students' and professional workers' (under 35 only) weekly computing hours.

Source	Sum of Squares	F Ratio	Prob > F
Gender	77.8098	0.3472	0.5562
Category	**1714.5783**	**7.6509**	**0.0061**
Category*Gender	161.5632	0.7209	0.3966

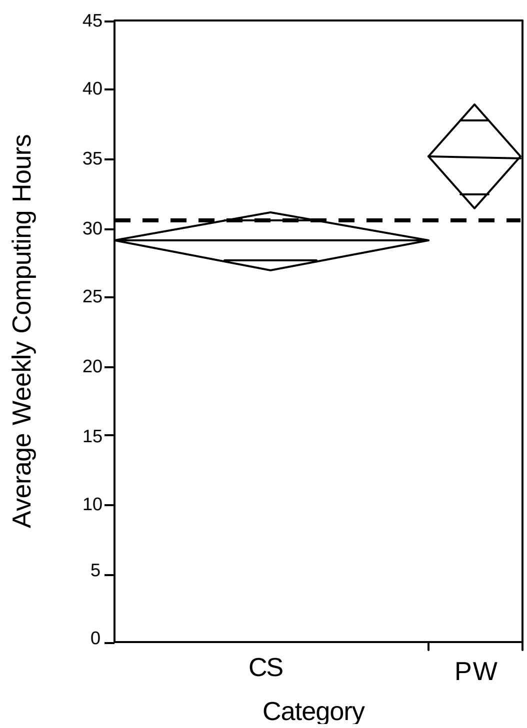

Figure 3.16: College students' and professional workers' weekly computer use by category.

3.3.3 Non-parametric Analysis

Table 3.12 is a summary of the Kruskal-Wallis test results to confirm the Wald Chi-Squared test on the non-parametric data. A p-value of less than .05 denotes statistical significance of the $\div^2$ value (Table 3.13).

Table 3.12: Results from the Kruskal-Wallis Test (One-Way Analyses) for college students' and professional workers' (under 35 only).

Dependent Variables	**Independent Variables**	$\div^2$	**Pr>** $\div^2$
PCPain	Category (CS or PW)	1.3609	0.2434
	Gender	**17.3035**	**<.0001**
UEPain	**Category (CS or PW)**	**13.0146**	**0.0003**
	Gender	**16.7181**	**<.0001**
PCSITSCR	**Category (CS or PW)**	**22.5523**	**<.0001**
	Gender	**3.9083**	**0.048**

3.3.3.1 Overall Reported Frequent Discomfort

When comparing the total reported frequent discomfort associated with computer use (PCPAIN) within the college students and professional workers, only Gender had a significant effect, with the total reported frequent discomfort greater for the females than for the males (Table 3.13 and Figure 3.17).

Table 3.13: Wald Chi-Squared results for college students' and professional workers' (under 35 only) PCPain

Source	Nparm	DF	Wald ChiSquare	Prob>ChiSq
Category	1	1	0.53344775	0.4652
Gender	**1**	**1**	**12.4490922**	**0.0004**
Category*Gender	1	1	0.06945061	0.7921

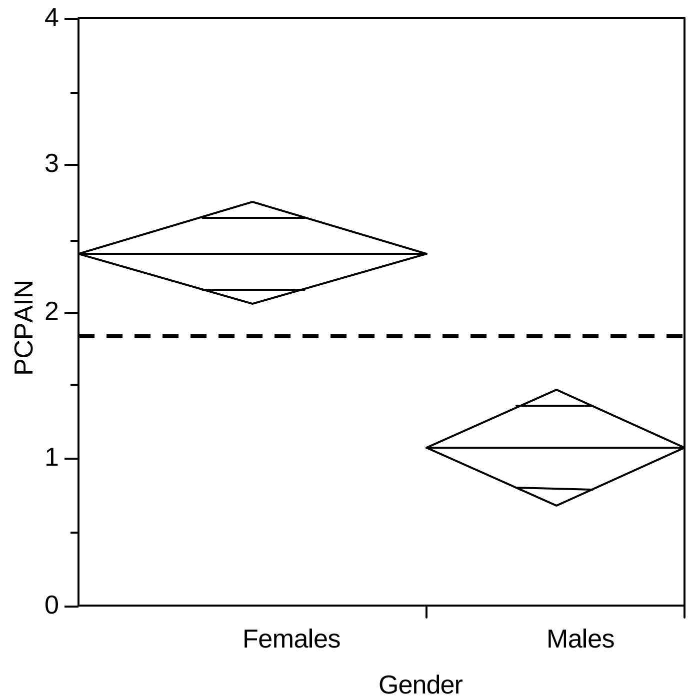

Figure 3.17: College students' and professional workers' (under 35) reported discomfort by gender.

3.3.3.2 Upper Extremity Reported Frequent Discomfort

When comparing the total reported frequent UE discomfort associated with computer use within the college students and professional workers, both subject Category and Gender had significant effects. The UEPain score was greater for college students than for the professionals, and the total reported frequent UE discomfort was greater for the females than for the males (Table 3.14, and Figures 3.18 and 3.19).

Table 3.14: Wald Chi-Squared results for college students' and professional workers' (under 35 only) for UEPain.

Source	Nparm	DF	Wald ChiSquare	Prob>ChiSq
Category	**1**	**1**	**11.1978597**	**0.0008**
Gender	**1**	**1**	**9.84321298**	**0.0017**
Category*Gender	1	1	0.01839122	0.8921

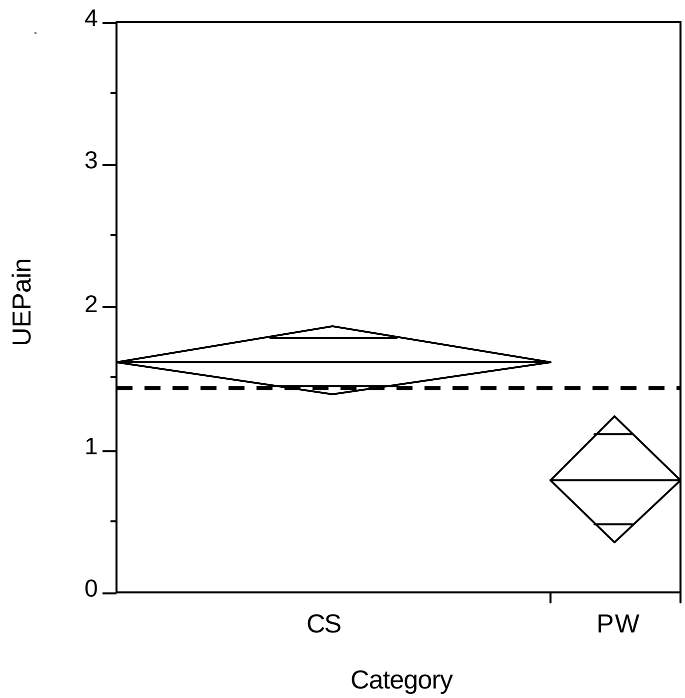

Figure 3.18: College students' and professional workers' (under 35) reported upper extremity discomfort by category.

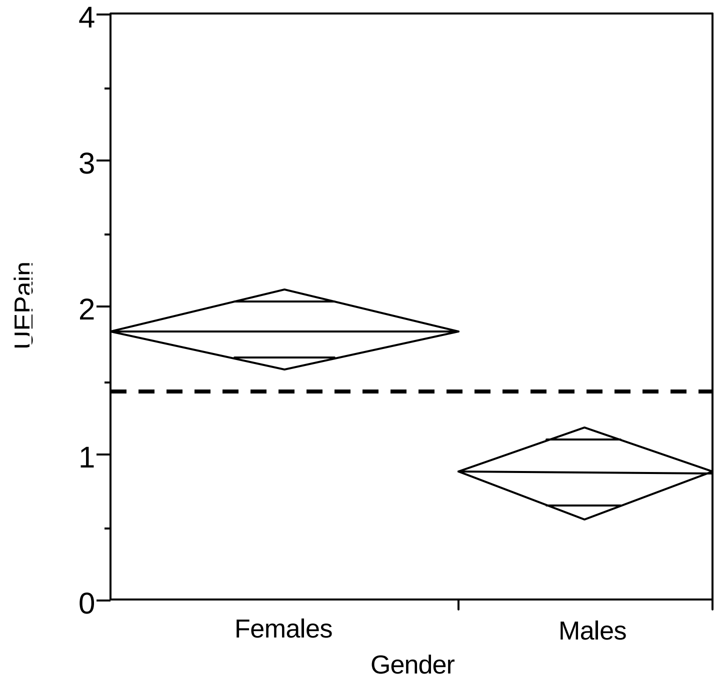

Figure 3.19: College students' and professional workers' (under 35) reported upper extremity discomfort by gender.

3.3.3.3 Composite Score of Continuous Time Sitting While Using the Computer Before Breaks (PCSITSCR)

When comparing the weighted time of computer use between breaks of 30, 60, 90, and 120 minutes (PCSITSCR), within the college students and professional workers, only Category had a significant effect, with the time between breaks being greater for the college students than for the professional workers (Table 3.15 and Figure 3.20). There was one disagreement between the results of the Kruskal-Wallis test and the Wald ChiSquared test. The Kruskal-Wallis test found gender to be significant while the Wald ChiSquared test did not. In the interest of completeness this response is shown in Figure 3.21.

Table 3.15: College students' and professional workers' PCSITSCR effect tests results

Source	Nparm	DF	Wald ChiSquare	Prob>ChiSq
Category	**1**	**1**	**23.6038879**	**<0.0001**
Gender	1	1	1.41553158	0.2341
Category*Gender	1	1	0.32011806	0.5715

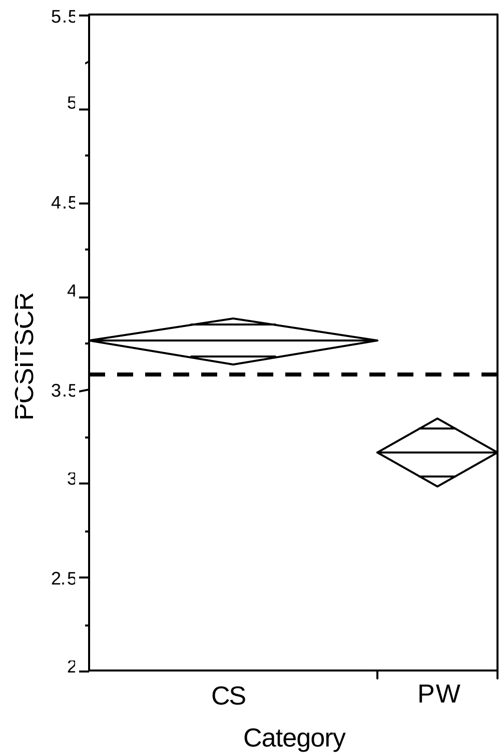

Figure 3.20: College students' and professional workers' (under 35) PCSITSCR by category.

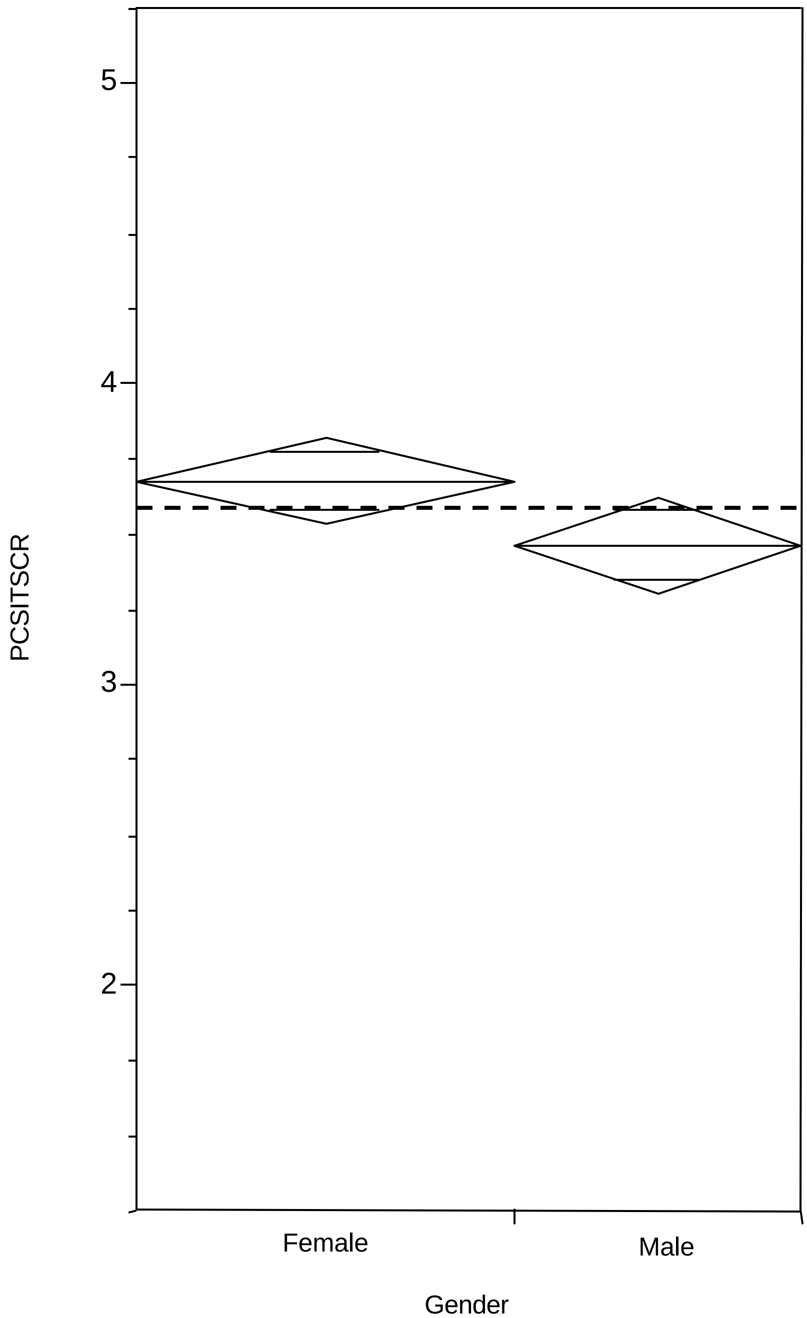

Figure 3.21: College students' and professional workers' (under 35) PCSITSCR by gender.

3.3.4 Correlation between Discomfort and Composite Score of Time Sitting

The correlation between the reported discomfort and likelihood of continuously sitting was 0.38 ($p<.0001$) across all subjects under age 35, suggesting a relationship between static positioning and discomfort (Figure 3.22).

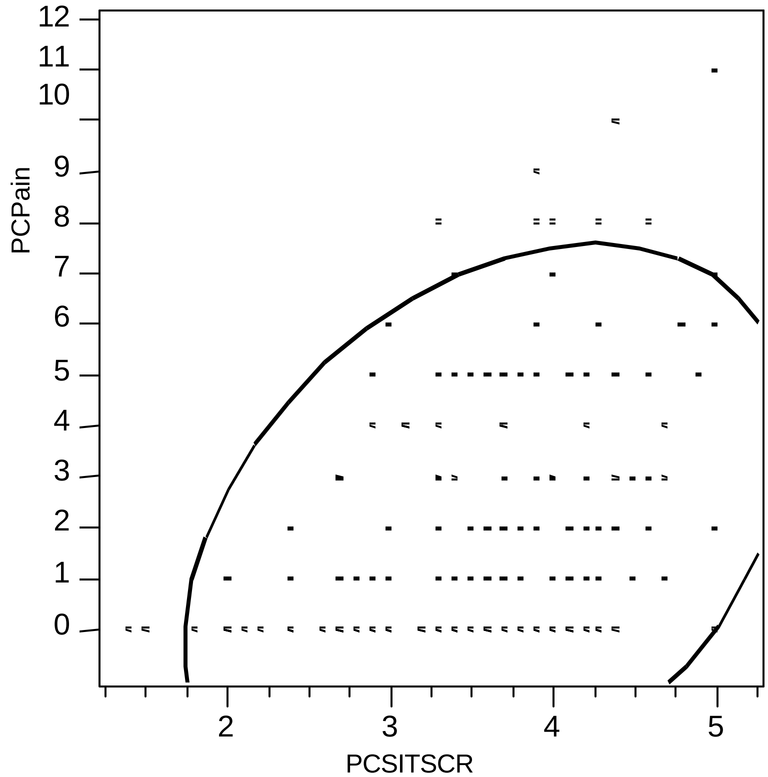

Figure 3.22: Correlation between PCSITSCR and PCPain for participants under 35.

4 DISCUSSION

4.1 Computing Patterns

Graduate students had reported greater computing hours than undergraduate students. The higher reported computing hours was expected, because graduate students are further into their education and are completing masters and doctorates requiring research and report writing. The significant differences occurred with graduates students reporting 24% (25.3) more computing hours than undergraduates (20.4) over weekday computer use, 23% more weekend computer use (graduates 7.6, undergraduates 6.2), and 24% greater overall weekly computer use (graduates 32.9, undergraduates 26.6). Previous studies of computer use reported undergraduate students working an average of 2.9 hours per day (Peper and Gibney 1999). By contrast the undergraduate students in this study reported closer to a daily average of 3.8 hours per day, and the graduate students, a daily average of 4.8 hours, based on weekly computer use. In the study by Peper and Gibney (1999) the research focused on undergraduate students in upper level classes. Peper and Gibney (1999) only asked about general daily computer use and not weekend/weekday computer use as current study has addressed. Inquiring about computing hours on specific days allowed for comparisons of computing hours on weekdays and weekends. On average college students in the current study worked more during the weekdays on the computer than the weekends. During the weekdays, the daily average of computing was reported as 5.1 hours for graduate students and 4.1 for undergraduate students. On the weekends, the hours were lower, with an average of 3.8 computing hours for graduate students and 3.1 for undergraduate students. Also notable was that graduate students were not included in the Peper and Gibney (1999) research, though in the current study class standing was found to be significant, with graduate students reporting more computing hours than undergraduates. Katz et al. (2002) associated computing hours with a higher prevalence of symptoms; more than 20 hours per week computing had an OR of 1.4 (CI 1.1 to 1.9). Both graduates and undergraduates in the current study averaged over 20 hours per week of computing. However Katz et al.(2002) only included undergraduate seniors, a much more limited scope of college students, and their survey inquired about general weekly computer use. The only study to include graduate students was the focus group by Cortés et al. (2002) which was qualitative research. In the study by Cortés et al. (2002) the research covered only symptomatic students, and it was a small sample of students, only 7 undergraduates and 9 graduate students.

Professional workers had greater reported computing hours than college students. Of the participants under 35, undergraduates had the lowest number of reported weekly computing hours, an average of 26.5 hours. Graduate students reported 33.7 hours, while professional workers reported 35.2 hours. These higher reported computing hours were expected since the professional workers' estimates of computing time at work and at home were combined to better compare with the college students' reported computing hours. The college students were not asked to specify which hours were for 'work' and which hours were for 'other', as the term 'work' may have been confusing to the college students. In the larger data set of the professional worker study, (derived from Sommerich (2002) data set with the over 35 year old subjects removed) participants' reported computer use was 5 hours per day (this value was calculated the same way as the variable 'Weekly' shown in Section 2.4.1).

Reported hours of both groups may not be a good estimate of actual computing hours. From Bernard et al. (1994), a study of newspaper employees leads this researcher to believe that both groups will over-report their hours. In Bernard et al (1994) study for workers with hand symptoms the reported hours were 4.5 (s.d. 2.6) and the observed typing hours were 2.5 (s.d. 1.4); this is an overestimate of typing hours by 80%. The inflation of reported typing hours is even higher in their referent group; an over-estimate of 100%, with the reported typing hours were 3.9 (2.1) and 1.9 (0.9). It is important to note that the degree of over reported computing hours was similar in both groups, however that study asked the participants their daily computer use and the current study was more specific of the college students specifying each day of the week. By allowing the participants to answer per the specific day, the estimates of computer usage could be more accurate and therefore the computing hours may not be as over-reported.

Another question referred to the likelihood of using a computer during specific periods of time. As a group, the professional workers reported that they were at least *Somewhat likely* to use a computer between 6:00 am and 6:00 pm. As a group, the college students reported a pattern of computer use over a greater range of times throughout the 24-hour day, reporting being at least *Somewhat likely* to use the computer between 8:00 am and 2:00 am. Under any category of use certainty (except 'Not Likely'), college students indicate more 2-hour usage periods than the professional workers. This would indicate that college students spread out their computer use over the 24-hour day, whereas professional workers concentrate their computer use into fewer hours. At this point, it is not obvious whether one pattern would be more or less harmful than the other. This would require further study.

The participants provided information as to how likely they were to sit continuously using the computer for X amount of time before taking a break, with increment breaks of 30, 60, 90, 120 minutes. The combined response for this set of questions was given the variable name PCSITSCR. A significant difference occurred, with graduate students' scores indicating longer periods of time sitting in front of the computer (PCSITSCR is 10% greater than undergraduates). Peper and Gibney (1999) inquired about break patterns similar to the current's study inquiry on time periods before breaks. However, Peper and Gibney (1999) did not quantify the time allocations; only the act of a break and the researchers deemed these alleviations of discomfort or pain rather than a common practice of healthy computing. In Katz et al. (2000), the researchers attributed differences in the number of reported computing hours within different academic concentrations to a work style effect. For example, "binge" computing would be more common within computer science versus history. This could also be true of graduate students meeting proposal/defense deadlines. In comparison, college students reported longer period of time sitting in front of the computer when compared with the professional workers. The PCSITSCR for college students yielded a weighted value of 3.8 (s.d. 0.7) and for the professional workers, 3.2 (s.d. 0.8). Therefore, in general college students worked on the computer for closer to 90 minutes before taking a break, while the professional workers worked closer to 60 minutes before taking a break. Galinsky et al (2000) study incorporated a five minute rest break every hour in addition to the conventional two-15 minute breaks during the day, and found significantly lower discomfort and no decrement in performance. Through an education program the importance of breaks may be further realized, discomfort due to computing, as observed from the Galinsky et al (2000) and possibly reduce MSSs and MSDs.

4.2 Discomfort

Females in both studies reported a higher frequency of discomfort associated with using a computer than the male participants. Discomfort in body part areas was summed if the reported discomfort of the response was *Quite often*, or *Almost always*. These higher reported frequencies of overall discomfort and upper extremity discomfort in female subjects were expected. With the college student comparison, the body areas with reported discomfort (PCPain) for females ranged from 0-12 of the 13 body areas described. The average value of reported discomfort was 2.4 (s.d. 2.6). In contrast the male participants reported discomfort in 0-7 of the body areas and an average discomfort of 1.2 (s.d. 1.5). The comparison of participants under 35 (both college students and professional workers under 35) was similar to the comparisons of college students alone. The overall reported discomfort (PCPain) for the female professionals under 35 ranged from 0-11 of the 13 body areas described, with an average reported discomfort in 2.4 (s.d. 2.5) of the body areas. In contrast the male participants reported a range of 0-7 and an average discomfort of 1.1 (s.d. 1.4) of the 13 body areas. Also, the previous study of professional workers yielded higher prevalence of discomfort in females (Sommerich 2002). The higher frequencies of reported discomfort continued in upper extremities of the current study. Frequent discomfort in the upper extremity (right forearm or elbow, left forearm or elbow, right shoulder, left shoulder, neck, upper back) was also computed, referred to as the variable UEPain. Female college students' average reported UEPain was 2.0 (s.d. 2.1) while the value for their male counterparts was 1.1 (s.d. 1.3).

The finding of higher reported frequency of discomfort in female participants follows other research. In Katz et al. (2000) the research, which was centered on college students, found similar results in reported discomfort in the hands, wrist and arms while computing. Katz et al. (2002) sampled a large number of graduating senior students, over a thousand students. Researchers associated the answer to the question "Do you experience pain, numbness, tingling , or other discomfort in you hands, wrist or arms when you use a computer" with some of the other items on the survey including student's gender, academic concentration (major), residential house, hours of computer use each week and participation in intercollegiate athletics. A greater prevalence of musculoskeletal symptoms occurred in the females, an odds ratio (OR) equal to 1.6 at a 95% confidence interval (CI). However, the study by Katz et al. (2002) did not include all areas of the body to indicate discomfort, only the UE were described. This current research found frequency patterns by gender in the UE, as Katz et al. (2002) found, but also found that the frequent whole body pain score, PCPain, was greater for female student s than for male students in the current study. Other research also supports that females report higher discomfort (Jensen et al. 2002, Blatter and Bongers 2002, Marcus et al. 2002). Bernard et al (1994), found that female newspaper workers were at a higher risk for neck (OR 2.1), shoulder (OR 2.2) and hand or wrist (OR 1.7) symptoms. Gerr et al. (2002) found gender associated with hand or arm and neck or shoulder MSS and

MSD. Females had a 1.6 (95% CI) Relative Risk (RR) for hand or arm symptoms, 1.7 (95% CI) for neck or shoulder symptoms, 2.4 (95% CI) for hand or arm disorders, and 1.9 (95% CI) for neck or shoulder disorders.

In addition to this, college students higher reported frequency of discomfort of UE discomfort than the professional workers, and this was not expected. Since office workers spent more time computing, this researcher was lead to believe that their discomfort would also have been more frequent. The higher level of UE discomfort reported by college students could be due to the varying work environments. College students use computers in a variety of locations: in the computer labs, the library, or their home computer. The configurations in the computer locations may be less apt to the postural needs of the varying college students that may use the computer. The most important component of computer labs is visible from the computer lab's farm-like appearance; the goal seems to be to provide the maximum number of stations, with the highest level of processing speed and software availability with the funds available. Due to this college students must adapt, balancing books and papers and assuming whatever posture possible. The availability of adjustable furniture may be limited or non-existent depending on the trade-off of funding (Royster and Yearout 1999). Research has found an association with limited or insufficient table space and neck/shoulder discomforts; other associations of neck/shoulder discomfort include the high positioning of the keyboard and VDT (Bergqvist et al. 1995). Along with discomfort, tension neck syndrome diagnosis has been associated with insufficient table space, and arm/hand discomfort has been associated with non-neutral or extreme hand positions

(Bergqvist et al. 1995). College students may not feel the urgency to take measures to prevent the pain. Cortés et al. (2002) in their focus groups of symptomatic college students, found that in general, the college students "did not feel their symptoms were serious enough" to report.

Within college students, the correlation between frequent discomfort and composite score of time sitting in front of a computer before a break was 0.35. The correlation between college students and professional workers under 35 was similar at 0.39. This was consistent with Sommerich's (2002) research showing a similar correlation of 0.31 found in the larger data set of the professional worker study. This continues to reiterate the need for education for computer users to take adequate rest breaks as increased rest breaks reduce discomfort (Galinsky 2000).

4.3 Limitations

In the current study there are several limitations to the current work that should be noted. There was a low response rate, with less than 50% of the college students completing the survey. Those college students that did not respond could not be contacted and therefore there is no assessment of the differences between respondents and non-respondents. Those that responded could easily have been students drawn to the nature of the study or more apt to volunteer for research, each are potential biases. In a few other studies a verification of the responses has been completed, such as comparisons of reported computing hours to actual observed computing hours; this was not completed in the current study.

This study did include a much more diverse population than previous studies. Both graduate and undergraduates were included. Forty percent of the students were graduate students. The students of two academic concentrations were included, humanities and social science (46%) and engineering (53%). A diverse sample of male and female students was also present in this study with 63% of sample being female students. Also, efforts were taken to control for duplicate responses. Each student was given a separate ID code, and those responses that had identical ID codes or no ID code were deleted.

If this study is considered as a pilot effort, suggested improvements in methods include performing more detailed analysis over a longer period of time, similar to the professional worker study. Along with the longer study time, following up to compare the actual versus reported values would have yielded an even further comparison to the professional worker's validated portion of the study. Including physical examinations or a detailed clinical assessment of those with symptoms could help further define the scope of the college student risk of MSDs.

4.4 Future Work

Following a group of college student throughout their academic career could also be a next step. College students could be medically evaluated and followed over time. Research into this younger population could further investigate the natural history of musculoskeletal disorders because college students begin using computers at an early age. Future professional workers are developing their computing habits at younger ages, in college or in other school levels.

Another next step would be to gather more information, such as that of the professional worker study with a larger response rate and sample size. Further defined work patterns could yield interventions directed at the college population to attempt to accommodate the user of a variety of computers, the various locations, during late hours, and all the other components that place college students at risk for developing MSDs. Also the comparison can made over time to determine if computer use plateaus among college students or increases, by comparing the two different time periods of studies.

Variations on these suggestions could include some students receiving one intervention technique versus another. This could determine the types of program that show effectiveness in the college setting. Such studies involving younger college students and younger professional workers, those with and without symptoms, may be further steps to placing interventions in colleges, universities, and other education systems as well

5 CONCLUSIONS

The motivations for this work to evaluate college student computer users derived from my concern as a college student and my growing interests in the study of ergonomics over the past three years. Before pursuing this study, the importance of incorporating ergonomics in the daily life of computer users became apparent but the education infrastructure was not presenting itself prominently at the university level.

Efforts to reduce exposures to risk factors associated with MSS and MSD should not only include the workforce, but those that are beginning on computers, including children in elementary school, middle school, and high school. After finding literature focused in these special populations, the college student seemed to be left out. College students are adults, therefore are not a special population when compared to a developing child. Proper workstation set-up and healthy computing are not common place terms in the education environment. Students at one university will need to dig through two links on the health services website which eventually links to a search engine's general health website, then two more links on this website before receiving any recommendations about healthy computing. On each website there is no clear direct path to healthy computing, so the student may become frustrated before they find advice on their own. As seen in other studies, health care professionals may not have much more to offer than 'limit computer use' as a primary suggestion (Cortés et al, 2002).

Of the research presented about college students skepticism existed in the ergonomics community about college students risk for MSDs. This research was aimed at illustrating risk factors substantiated by literature that appear in college students.

The most important results are the similarities in college students and professional workers. As college students continue into advanced degrees and become graduate students the amount of computer use on a weekly basis is very similar to the professional workers. College students in general reported a higher frequency of discomfort than professional workers and this is discerning. Also, college students reported computing patterns from early in the morning until late in the evening, much later in the evening than the professional workers. Since college students have similar computing hours and higher frequency of discomfort, the reporting of college students with MSDs in other studies is not surprising.

Since Major was not found to significantly affect any of the variables in this study, these results imply that college students' computer knowledge about MSDs needs to be addressed at the university level. College students are more likely to enter the workforce with poor computing habits, MSS, or even a MSD, without some intervention. At least with the knowledge about MSDs and MSSs, college students can know how to set-up their primary workstation to promote healthier computing. With knowledge, a college student experiencing symptoms may find information on elevation of the symptoms before they progress to a permanent problem.

The only known defenses to MSSs and MSDs are prevention or intervention. Universities not providing healthy computing training and instruction, while at the same time requiring ownership of a computer may be opening their doors to lawsuits. Workstations on campus may also be contributing to college students' development of MSSs and MSDs. A new inclusion in Universities' computer budgets will also need to provide for proper computer equipment to allow for students to adjust the workstation to their individual needs as well as training on how to use the equipment. Knowledge and proper equipment are two items that could help offset a future workforce's probability for developing computer related Musculoskeletal Disorders.

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United States Department of Commerce, U.S. Census Bureau, Current Population Survey: Computer Use and Ownership data, Washington October 1984. Table 4. Use of Computers at Home by People 18 years and older. (http://www.census.gov/population/socdemo/computer/p23-155/tab04.pdf [accessed 3/9/01]).

United States Department of Commerce, U.S. Census Bureau. (2000). The PC Generation: Computer Use, 2000 [Electronic version]. Population Profile of the United States: 2000, 10, 1-2.

United States Department of Labor, Bureau of Labor Statistics. (2001). Days away from work highest for carpel tunnel syndrome. MLR: The Editor's Desk. Retrieved February 7, 2003 from http://www.bls.gov/opub/ted/2001/apr/wk1/art01.htm.

United States Department of Labor, Bureau of Labor Statistics. (2000). Cases involving sprains, strains, and tears; carpal tunnel syndrome; and tendonitis: Supplemental tables. Retrieved January 17, 2003 from http://www.bls.gov/iif/oshwc/osh/case/ostb0668.pdf.

Computer Industry Almanac Inc. (2003) Worldwide Cumulative PC Sales exceed 1 billion. Retrieved March 8, 2003 from http://www.c-i-a.com/pr0203.htm.

APPENDIX A: RESIDUAL PLOTS

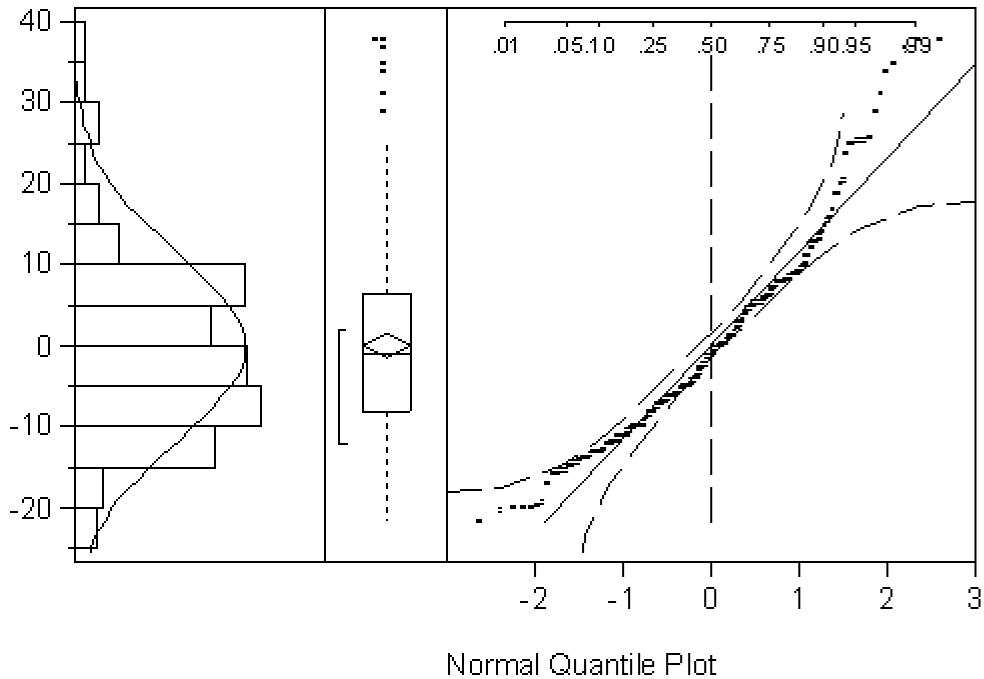

Figure A.1: Plot of college students' weekday computer use residuals.

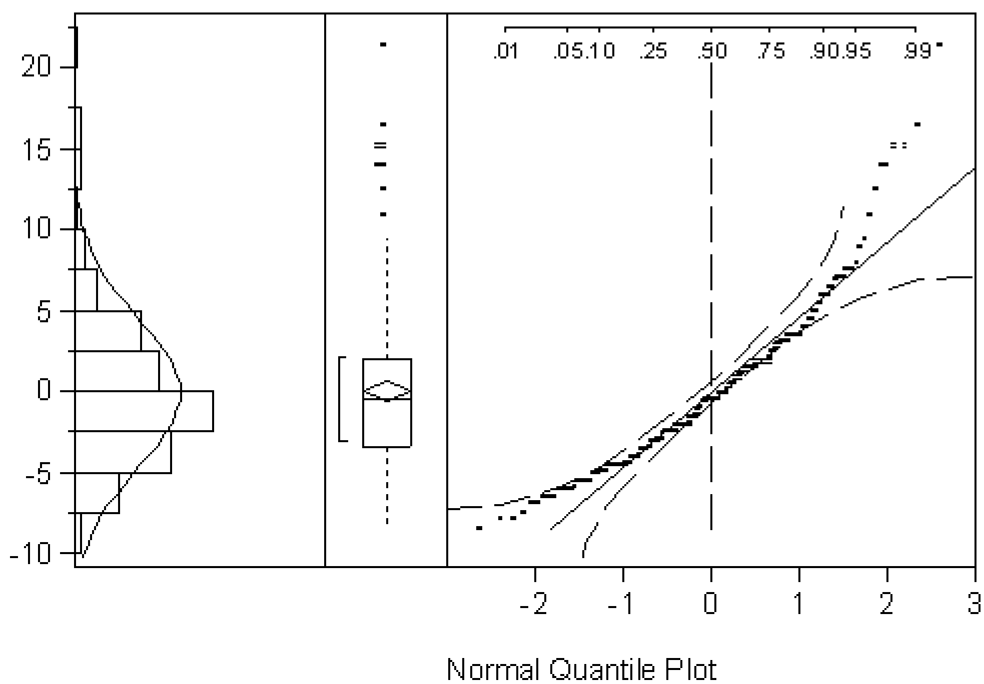

Figure A.2: Plot of college students' weekend computer use residuals.

APPENDIX A: RESIDUAL PLOTS

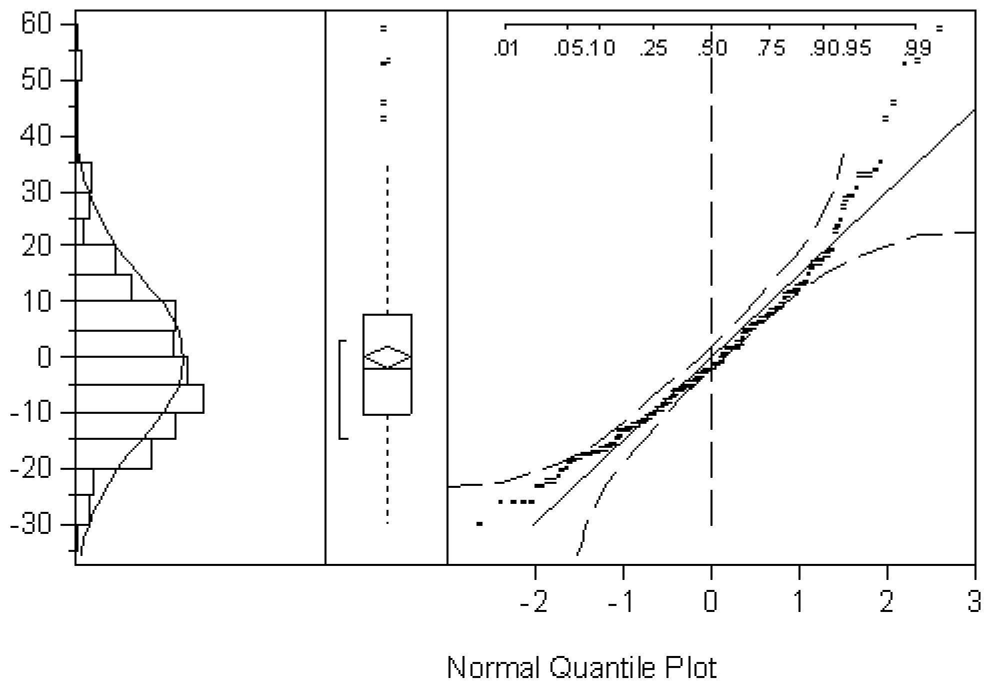

Figure A.3: Plot of college students' weekly computer use residuals.

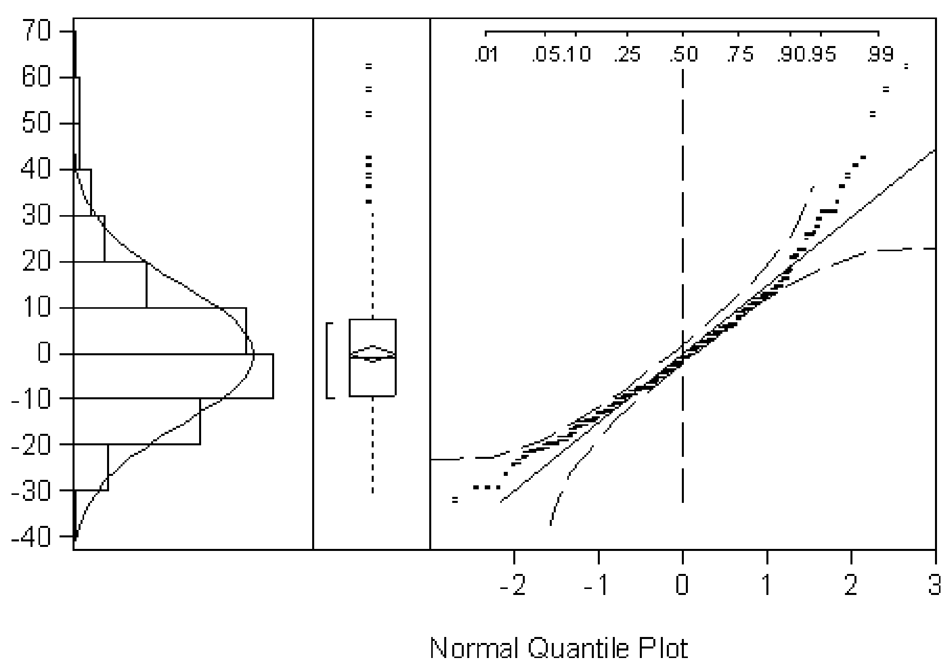

Figure A.4: Plot of weekly computer use residuals for college students' and professional workers under 35.

APPENDIX B: RESIDUAL VERSUS PREDICTED VALUES PLOTS

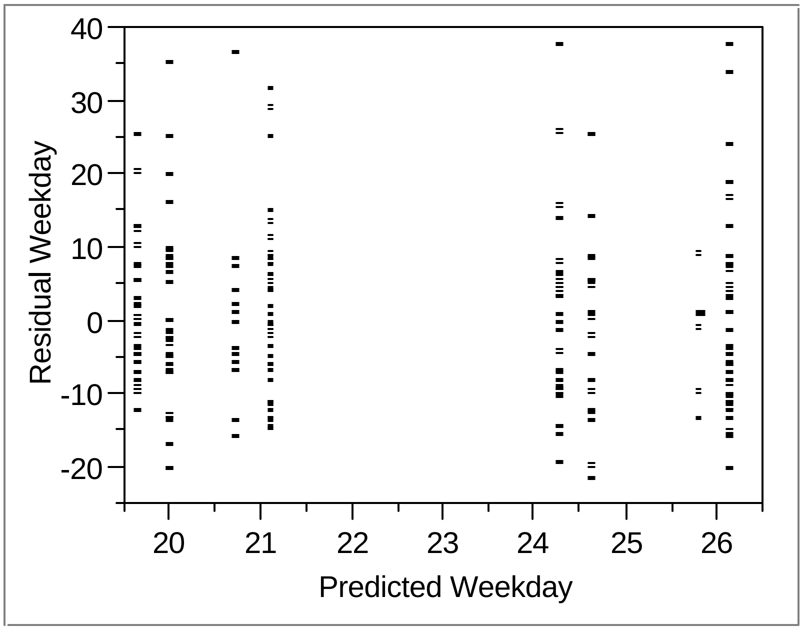

Figure B.1: Plot of college students' weekday computer use residuals versus predicted values.

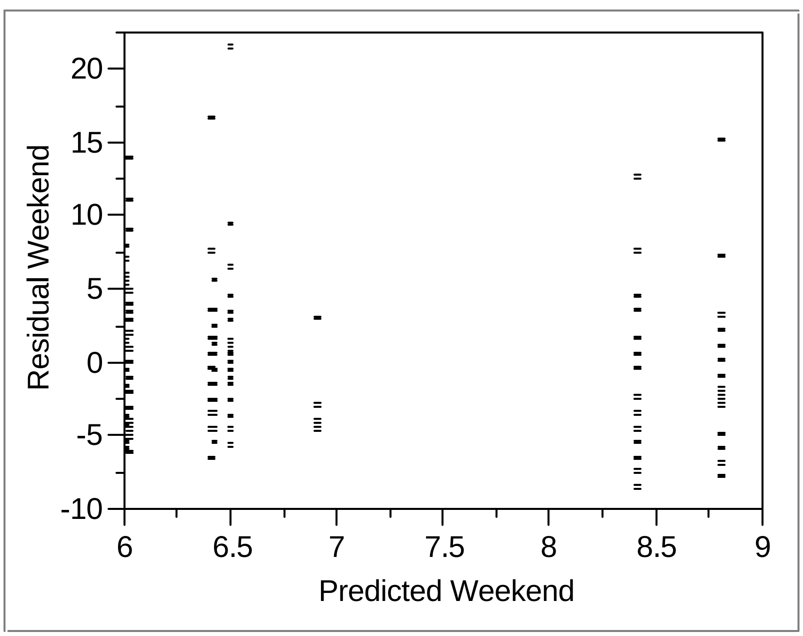

Figure B.2: Plot of college students' weekend computer use residual versus predicted values.

APPENDIX B: RESIDUAL VERSUS PREDICTED VALUES PLOTS

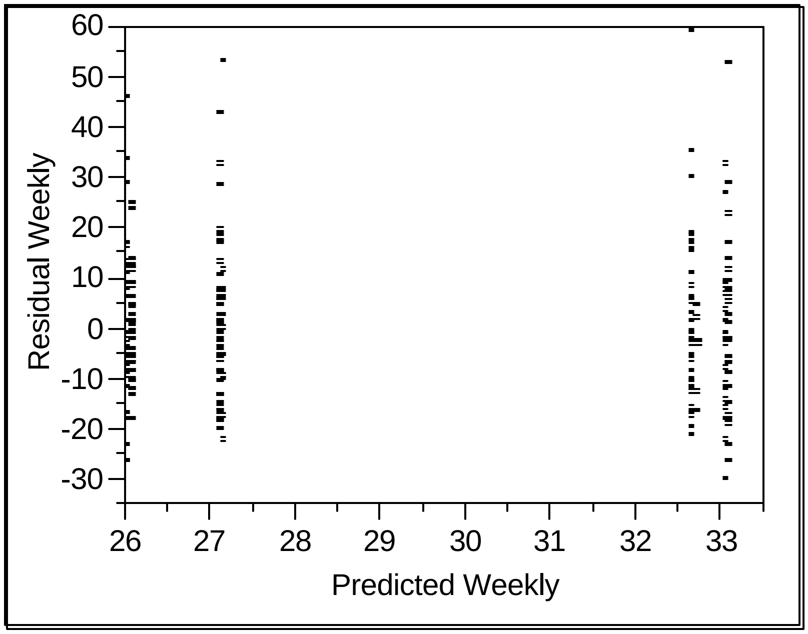

Figure B.3: Plot of college students' weekly computer use residual versus predicted plot values

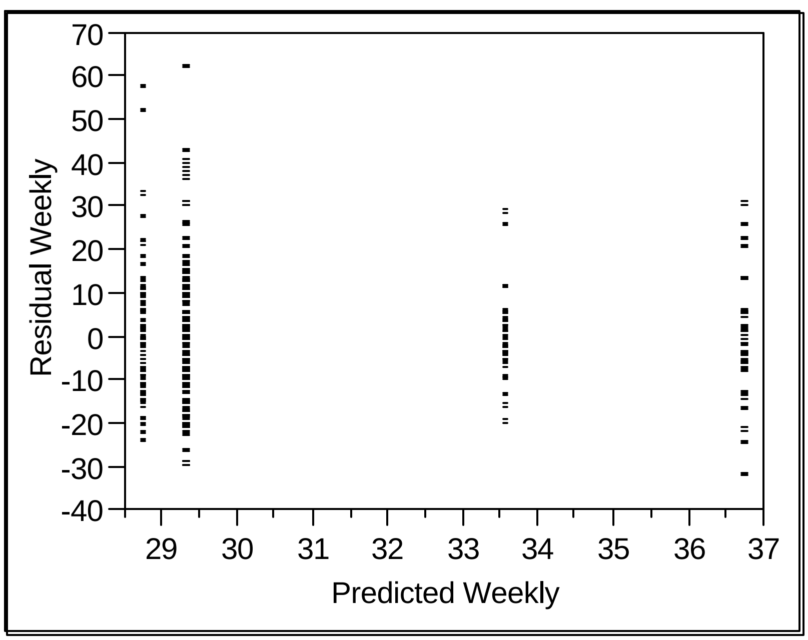

Figure B.4: Plot of weekly computer use residual versus predicted values for college students' and professional workers under 35

APPENDIX C: COLLEGE STUDENT SURVEY INSTRUMENT

Computer Usage Survey
for College Students

Contact Information

Name: Karen
Email: klnoack@unity.ncsu.edu

1. Code

[Top] [Code] [Consent] [Computer] [Demographics] [Submit]

1.1. Type in the code. If you do not have a code, email me at klnoack@unity.ncsu.edu.

2. Informed Consent

[Top] [Code] [Consent] [Computer] [Demographics] [Submit]

2.1. You are invited to participate in a research study of student computer use. The following survey asks you questions about when, where and how long you use a computer. Participation in this survey is completely voluntary and should take no more than 20 minutes. If you agree to participate you are not obligated to answer any of these questions. Please check "yes" indicating that you have read this paragraph and understand what you are being asked to do for this study.

Yes No

Computer Information

[Top] [Code] [Consent] [Computer] [Demographics] [Submit]

3.1. How often do you use a computer in a typical week?

- Never (skip to the Demographics section)
- At least once during the week
- Most days
- Every day

3.2. What types of computers do you use? (Mark all that apply)

- Desktop
- Notebook/Laptop

3.3. Do you use computers at: (Mark all that apply)

- Home (your permanent address)
- Home (your campus address, if different)
- Campus Home
- Computer lab

- ☐ Library - rented notebook or lab
- ☐ Other, Please Specify: [ ]

3.4. What kinds of software applications do you use? (Mark all that apply)

- ☐ Word processing
- ☐ Database management
- ☐ Internet/ World Wide Web access
- ☐ Work/ Company Intranet
- ☐ Email
- ☐ Simulation
- ☐ Spreadsheet
- ☐ Presentation
- ☐ Data analysis
- ☐ Computer program
- ☐ CAD/ CAM
- ☐ Web page design
- ☐ Graphics
- ☐ Time management
- ☐ Voice recognition/ voice activated
- ☐ Other, Please Specify: [ ]

3.5. During a typical day, how much time do you spend using a computer? Do not include the time that it is turned on, but when you are actually using it. If your usage varies from day to day, provide the range of hours that you typically use the computer, otherwise enter a single value. For example: for a schedule that varies, you might enter "3.5-5" hours/day; for usage that is pretty steady, you might enter "4.5" hours/day.

		Desktop	Notebook/Laptop
a.	Monday		
b.	Tuesday		
c.	Wednesday		
d.	Thursday		
e.	Friday		
f.	Saturday		
g.	Sunday		

3.6. How likely are you to use the computer on the days listed below:

		Not likely	Somewhat	Pretty likely	Very likely
a.	Monday				
b.	Tuesday				
c.	Wednesday				
d.	Thursday				
e.	Friday				
f.	Saturday				
		Not likely	Somewhat	Pretty likely	Very likely
g.	Sunday				

3.7. On days that you use the computer, how likely are you to use it within each of the time periods listed below:

		Not likely	Somewhat likely	Pretty likely	Very likely
a.	12 midnight - 2 a.m.				
b.	2-4 a.m.				
c.	4-6 a.m.				
d.	6-8 a.m.				
e.	8-10 a.m.				
f.	10 a.m. - 12 noon				

		Not likely	Somewhat likely	Pretty likely	Very likely
g.	12 noon - 2 p.m.				
h.	2-4 p.m.				
i.	4-6 p.m.				
j.	6-8 p.m.				
k.	8-10 p.m.				
l.	10 p.m. - 12 midnight				

3.8. When using the computer, I find myself assuming awkward, uncomfortable or "poor" postures?

		Never	Rarely	Sometimes	Quite often	Almost always
a.	Desktop					
b.	Notebook/ Laptop					

3.9. When work at the computer, how often do you sit continuously?

	Never	Rarely	Sometimes	Quite Often	Almost always
a. ... for more than 30 minutes	☐	☐	☐	☐	☐
b. ... for more than 60 minutes	☐	☐	☐	☐	☐
c. ... for more than 90 minutes	☐	☐	☐	☐	☐
d. ... for more than 120 minutes	☐	☐	☐	☐	☐

3.10. When using the computer, or after using it, how often do you experience any physical discomfort (such as stiffness, soreness, aching, numbness, tingling, pain, etc.) in the areas listed below?

	Never	Rarely	Sometimes	Quite often	Almost always
a. Right hand or wrist	☐	☐	☐	☐	☐
b. Left hand or wrist	☐	☐	☐	☐	☐
c. Right forearm or elbow	☐	☐	☐	☐	☐
d. Left forearm or elbow	☐	☐	☐	☐	☐
e. Right shoulder	☐	☐	☐	☐	☐
f. Left shoulder	☐	☐	☐	☐	☐

		Never	Rarely	Sometimes	Quite often	Almost always
g.	Neck	☐	☐	☐	☐	☐
h.	Upper back	☐	☐	☐	☐	☐
i.	Lower back	☐	☐	☐	☐	☐
j.	Buttocks	☐	☐	☐	☐	☐
k.	Eyes (burns, itch, dry, sore, etc.)	☐	☐	☐	☐	☐
l.	Headache	☐	☐	☐	☐	☐
		Never	Rarely	Sometimes	Quite often	Almost always
m.	Legs	☐	☐	☐	☐	☐

4. Demographic Information

[Top] [Code] [Consent] [Computer] [Demographics] [Submit]

4.1. What year were you born?

4.2. Your sex?

- ☐ Male
- ☐ Female

4.3. Indicate your race/ethnic origin. (Mark all that apply)

- ☐ African-American/Black
- ☐ Asian
- ☐ Caucasian/White
- ☐ Hispanic/Latino
- ☐ Inuit/Aluet/Alaskan Native
- ☐ Native American
- ☐ Pacific Islander
- ☐ Other

4.4. What is your class standing? (Mark all that apply)

- ☐ Freshman
- ☐ Sophomore
- ☐ Junior
- ☐ Senior
- ☐ Graduate student
- ☐ Other

4.5. College(s)

____

4.6. Major(s)

____

4.7. Prior to attending college, when did you use computers? (Mark all that apply)

- ☐ High school
- ☐ Middle school
- ☐ Grade school
- ☐ Home
- ☐ None
- ☐ Not sure

Submit Survey Responses

This survey was created using the

SurveySuite Survey Generation Tool

by

INTERCOM

Your Link to the World of Internet Commerce

University of Virginia

APPENDIX D: SELECTED QUESTIONS FROM PROFESSIONAL OFFICE WORKER STUDY

Question similar to Number 3.3
Where do you work with this computer? Mark all that apply.

- One of my employer's primary facilities
- Vendor or client facility
- Home office
- Other location (describe in the next question)

Question similar to Number 3.4
What kinds of software applications do you use for work on the computer? Mark all that apply.

- Word processing
- Database management
- Internet / World Wide Web access
- Company Intranet
- Email
- Simulation
- Spreadsheet
- Presentation
- Data analysis
- Computer program development
- CAD/CAM
- Web page design
- Graphics
- Time management
- Voice recognition / voice activated
- Others (please list in next question)

If there are other kinds of software applications that you use that were not listed in the previous question, please list them here.

APPENDIX D: SELECTED QUESTIONS FROM PROFESSIONAL OFFICE WORKER STUDY

Question similar to Number 3.5
During typical work days, how much time do you spend using a computer for work? Do not include the time that it is turned on, but you are not actually using it.

If your usage varies from day to day, provide the range of hours that you typically use the computer for work; otherwise, enter a single value. (For example: for a schedule that varies, you might enter " 3.5 - 5" hours/day; for usage that is pretty steady, you might enter "4.5" hours/day.)

Usage, in hours/day

Question similar to Number 3.7
On days that you use the computer for work, how likely are you to use it for work within each of the time periods listed below?

	Not likely	Somewhat likely	Pretty likely	Very likely
12 midnight - 2 a.m.	○	○	○	○
2-4 a.m.	○	○	○	○
4-6 a.m.	○	○	○	○
6-8 a.m.	○	○	○	○
8-10 a.m.	○	○	○	○
10 a.m. - 12 noon	○	○	○	○
12 noon - 2 p.m.	○	○	○	○
2-4 p.m.	○	○	○	○
4-6 p.m.	○	○	○	○
6-8 p.m.	○	○	○	○
8-10 p.m.	○	○	○	○
10 p.m. - 12 midnight	○	○	○	○

APPENDIX D: SELECTED QUESTIONS FROM PROFESSIONAL OFFICE WORKER STUDY

Question similar to Number 3.8
When using the computer, I find myself assuming awkward, uncomfortable, or "poor" postures.

○ Never ○ Rarely ○ Sometimes ○ Quite Often ○ Almost Always

Question similar to Number 3.9
When working at the computer, how often do you sit continuously ...

	Never	**Rarely**	**Sometimes**	**Quite Often**	**Almost Always**
...for more than 30 minutes	○	○	○	○	○
...for more than 60 minutes	○	○	○	○	○
...for more than 90 minutes	○	○	○	○	○
...for more than 120 minutes	○	○	○	○	○

APPENDIX D: SELECTED QUESTIONS FROM PROFESSIONAL OFFICE WORKER STUDY

Question similar to Number 3.10
When using the computer, or after using it, how often do you experience any physical discomfort (such as stiffness, soreness, aching, numbness, tingling, pain, etc.) in the areas listed below?

	Never	Rarely	Sometimes	Quite Often	Almost Always
Right hand or wrist	○	○	○	○	○
Left hand or wrist	○	○	○	○	○
Right forearm or elbow	○	○	○	○	○
Left forearm or elbow	○	○	○	○	○
Right shoulder	○	○	○	○	○
Left shoulder	○	○	○	○	○
Neck	○	○	○	○	○
Upper back	○	○	○	○	○
Lower back	○	○	○	○	○
Buttocks	○	○	○	○	○
Legs or feet	○	○	○	○	○
Eyes (burn, itch, dry, sore, etc.)	○	○	○	○	○
Headache	○	○	○	○	○

Question similar to Number 4.1
In what Year were you born?

APPENDIX D: SELECTED QUESTIONS FROM PROFESSIONAL OFFICE WORKER STUDY

Question similar to Number 4.2
Your sex?

Do not click the link of your answer, **until** after you've clicked in the circle next to your answer.

○ Female [Go to question 88]

○ Male [Go to question 90]

Question similar to Number 4.3
Indicate your race/ethnic origin. Mark all that apply.

☐ African-American/Black

☐ Asian

☐ Caucasian/White

☐ Hispanic/Latino

☐ Inuit/Aluet/Alaskan Native

☐ Native American

☐ Pacific Islander

☐ Other

Question similar to Number 4.7
When did you start using a computer for any purpose?

Year you started using computers: ________